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ON THE COVER

BECAUSE no information was available on winter weather conditions in the mountainous British Columbia section through which a 50-mile high-tension line will carry current from the Kemano powerhouse to the aluminum reduction works at Kitimat, a test span was erected for study during the cold season of 1950. Facts about the probable intensity of ice loading were especially sought in order that towers and cables might be designed to withstand the strain. Our cover picture shows the span between two 26-foot aluminum towers standing at an altitude of 5350 feet, the highest point in Kildala Pass.

The bleak site is well above timber line and in a glaciated region that has left rock exposed at the surface in most places. Remnants of glaciers exist nearby. Note the helicopter in the background which carried in men and materials. Recording instruments were set up at the span and observers were stationed in cabins at various points along the route to gather data on snowfall, temperatures, etc.

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IN THIS ISSUE

THERE probably isn't a major city in the world that rests on as honeycombed a subsurface as does Paris, France. Even so, that metropolis is weighing the possibility of relieving traffic congestion by digging more tunnels and chambers beneath its streets to serve as motor roads and parking places, the latter large enough to accommodate 1000 cars each. Our leading article, in two parts, tells the story of subterranean Paris that takes the reader back to 50 B. C. when the underground maze had its beginning.

•

TO HELP farmers who depend on irrigation to grow their crops and to save water impounded at great expense, the U. S. Bureau of Reclamation undertook, in 1946, to make a thorough study of canals and laterals for the primary purpose of lowering their first cost and maintenance charges. Its findings have recently been published in a report that is summarized in the article on page 278 entitled *Lining Irrigation Canals.*

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THE third and concluding installment of the article on *Aluminum Venture in British Columbia* starts on page 282.

Compressed Air Magazine

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VOLUME 57 **October, 1952** NUMBER 10

G. W. MORRISON, *Publisher*
C. H. VIVIAN, *Editor* J. W. YOUNG, *Director of Advertising*
ANNA M. HOFFMANN, *Associate Editor* J. J. KATARBA, *Business Mgr.*
J. C. PIERCE, *Assistant Editor*
A. W. LOOMIS, *Assistant Editor*
D. Y. MARSHALL, Europe, 243 Upper Thames St., London, E. C. 4.
F. A. McLEAN, Canada, New Birks Building, Montreal, Quebec.

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A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

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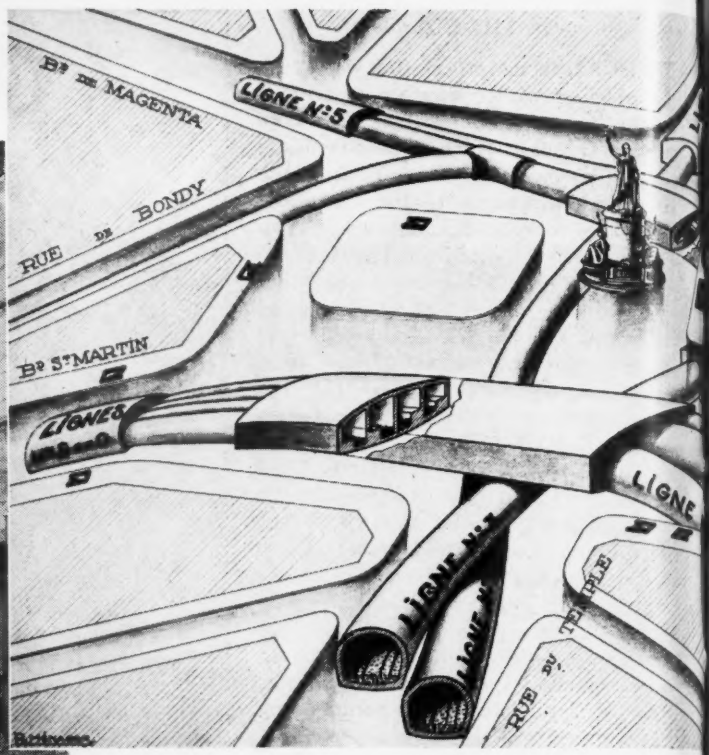
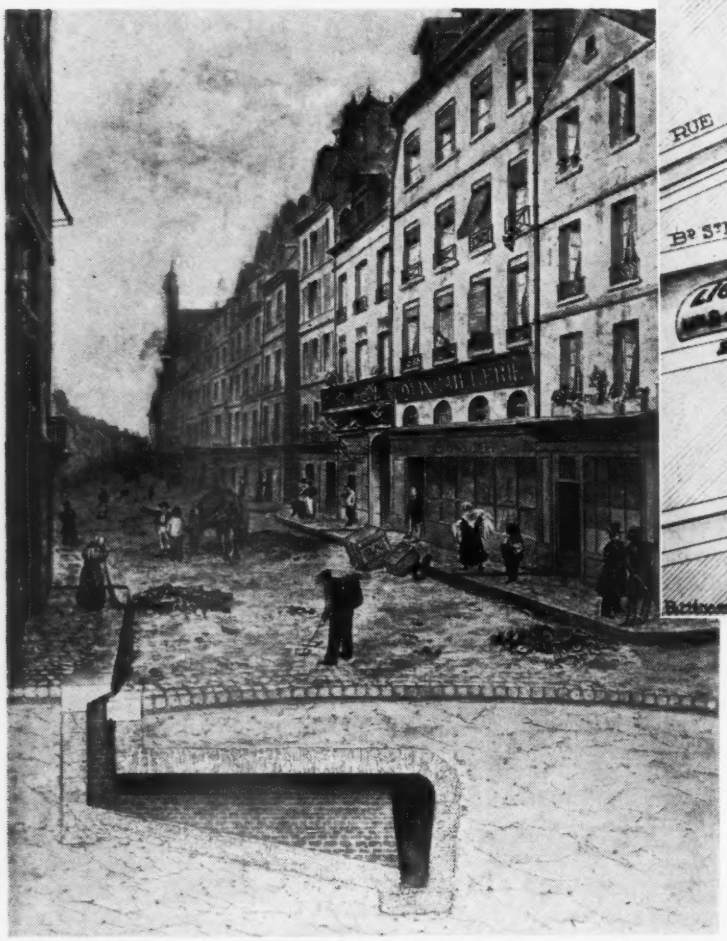
Published by Compressed Air Magazine Co., G. W. MORRISON, *President;* C. H. VIVIAN, *Vice-President;* A. W. LOOMIS, *Vice-President;* J. W. YOUNG, *Secretary-Treasurer.*
Editorial, advertising, and publication offices, Phillipsburg, N. J.
New York City Office, 11 Broadway. L. H. GEYER, *Representative.*
Annual subscription: U.S., $3.00, foreign, $3.50. Single copies, 35 cents.
COMPRESSED AIR MAGAZINE is on file in many libraries and is indexed in Industrial Arts Index and in Engineering Index.

SUBSURFACE MAZE

Right, layout of the most complicated area in the Metro system where five lines cross at three levels under Place de la Republique.





EARLY SEWER

The first sewers were under the centers of the streets, and surface water entered through grated openings directly overhead. Around 1830 they were modified by providing gutters for drainage, as shown in this reproduction of a painting. These served until 1852.

Paris Underground

Excavating of Some Sort Has Been Going On Under French Capital for 2000 Years

G. J. Constantini

Part 1

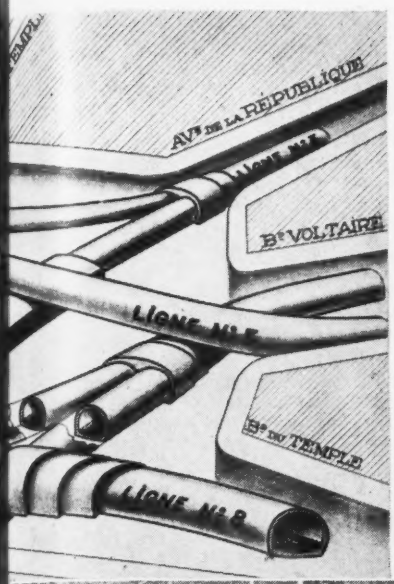
WHEN the world's large cities were growing in size, it became necessary, to prevent congestion, to go underground to provide means of rapid transportation as well as water- and gas-supply systems, power cables and other utilities. Every one was faced with much the same problem which, if the formations encountered were not stable, was fraught with difficulties. That was not the case in Paris, France, which is underlain mainly by limestone, gypsum and clay.

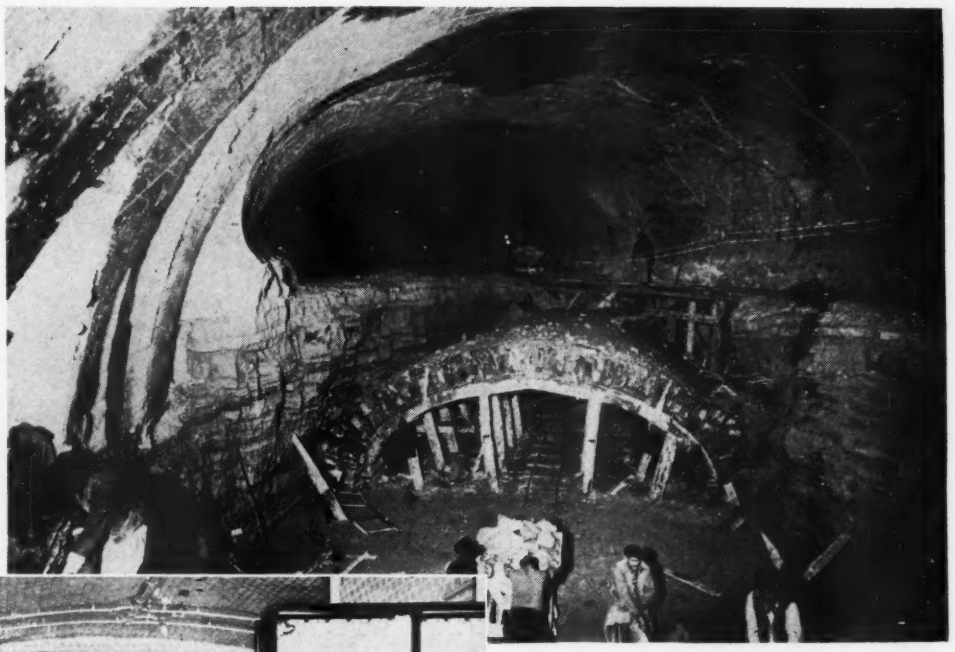
Quarries

At present, underground Paris, with its thousands of miles of tunnels and galleries, can be compared to a giant anthill. According to existing records, digging started there back in 50 B.C. At that time the Gallo-Romans were established in Lutèce—the Roman name for Paris—and needed material to build their houses, bridges, aqueducts, etc. They found an abundance of clay for making tiles and blocks, limestone for structural purposes and gypsum for plaster below ground and began quarrying operations on one or two levels. In the oldest workings only part of the material was extracted, leaving columns to support the roof; later all the material was removed and pillars were constructed for the purpose. The height of the different quarries varied from 6 to 15 feet for limestone and from 20 to 45 feet for gypsum.

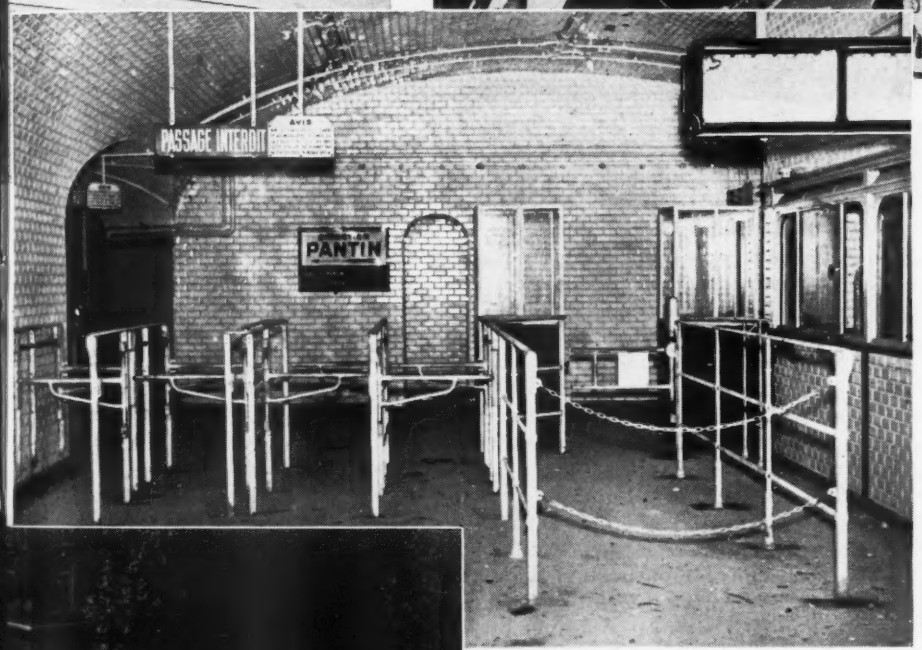
Access to the workings was provided either by excavating adits in hillsides at the same levels as the strata to be quarried, or by sinking small-diameter shafts. In most cases operations were carried on underground because open-pit work would have involved the removal of a great amount of overburden. Those ancient quarries were productive from the first century B.C. up to the eighteenth, and most of the houses of old Paris were built of material obtained from them.

In those days no definite mining plan was followed, and there were no safety regulations. Cave-ins because of insufficient support caused frequent acci-





CONSTRUCTION INTERSECTION
Workers excavating a huge cavern where two subway lines will cross on different levels. The arch of the lower passageway has been partially built and the bottom section remains to be taken out.



GATEWAY TO TRAINS
Above, interior of one of the 280 Paris subway stations with ticket booths at the right. Walls and ceiling are lined with ceramic tile.

ENTRANCES TO THE METRO
Place de l'Opera, showing two openings with stairways leading to the underground transit system.

dents. In 1774, 1775 and 1776, after a number of important streets had subsided with serious results, the government decided to create a special department, called Service d'Inspection Générale des Carrières, to take charge of the quarries and see to it that they were adequately strengthened when mining ceased.

Finally, in 1813, a law was enforced prohibiting quarrying under Paris. Since then all openings have been closed, workings that needed support have been made safe, and others that really were a menace have been filled in. In addition, all the abandoned underground areas have been accurately spotted on a map that has been of great aid to geologists, architects and engineers who have constructed the city's sewers and subways and continues to be of value to them.

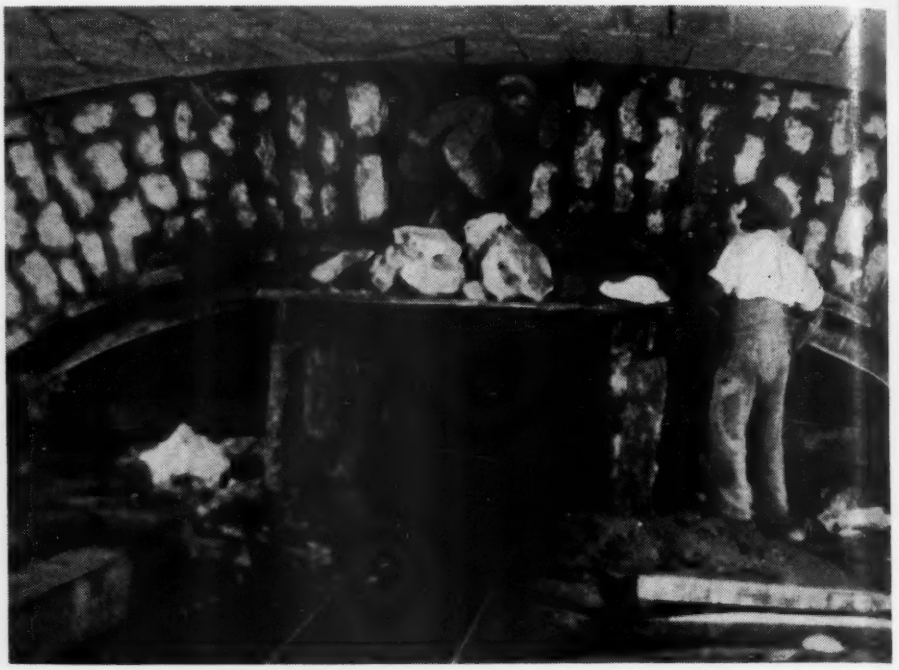
Some idea of the magnitude of the quarries can be obtained from the fact that they cover more than 2100 acres, are connected by 200 miles of galleries, and were reached by 216 shafts and 54 adits. The area involved represents about one-twelfth of Paris proper, and if the law of 1813 had not been passed, at least four-tenths of the city's foundation would have been honeycombed in that fashion.

The quarries have always played an important part in the history of Paris. At one period or another, outlaws, tramps and revolutionists sought refuge there from police, and during the two world wars they served Parisians as air-raid shelters. But the most original use to which they have been put dates back to the sixteenth century when cemeteries, located in the heart of the city, were overcrowded. Plans by the municipal authorities to remove the skeletal remains to some of the old workings met with considerable opposition, especially by the clergy, but they were carried out nevertheless.

From 1792 to 1883 most of the burial grounds were cleared and bones were neatly piled without distinction between supporting pillars and against the quarry walls. These catacombs, accessible to sight-seers by stairs and shafts, cover about three acres and are interconnected by 2500 feet of galleries. They are the resting places of some five to six million Parisians, including writers, artists, poets and other celebrities.

TOP-HEADING TUNNELING

By this method of excavating, which has been extensively practiced in Europe, a small heading of rectangular section (below) is first driven at the top of the area to be removed and then widened on both sides. Next an arch is built (right) and the lower part taken out by benching under this protective covering.



Sewerage System

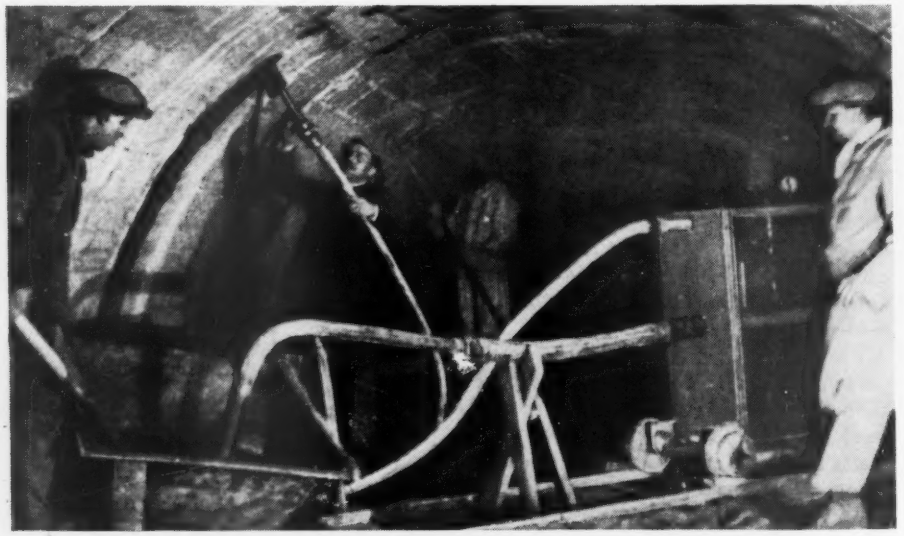
At the end of the seventeenth century, while France was at the height of her artistic and literary glory, her principal city depended mainly on 32,000 feet of open cuts to wash her refuse into the River Seine. Her underground sewerage system was only 7000 feet long, and did not exceed 12 miles by 1800. Construction was slow and difficult because all the heavy rock work had to be done by hand. In 1852 it was decided to eliminate the open drains and to connect every building in Paris with sewers to be run under each street. That was a tremendous undertaking, and was entrusted to Belgrand. At the time of his death the system was 375 miles long and drained 16,375 of the 18,750 acres, then the extent of the city, into the Seine at a point a few miles downstream.

In 1894, when the length had increased to 580 miles, it was proposed that the fertilizing properties of the sewage be used for agricultural purposes. That plan was adopted, despite protest, and since 1899 no city waste has been emptied into the river. For some years it was carried to the outskirts of Paris about 15 miles distant, where it was discharged onto fields covering 11,250 acres. Soon that area became insufficient, and in 1905 the drainage system was modernized by the establishment of a series of purification plants using bacteriological methods.

The Paris sewers are oval in section and are cut in rock and lined with concrete. The trunk or main lines are from 12 to 18 feet wide and 12 to 15 feet high and have sumps from 7 to 12 feet wide and 4 to 6 feet deep. From most of the basins the waste drains by gravity, but in the case of certain low areas it must be raised by means of centrifugal pumps or ejectors installed in six permanent plants. In addition to the latter there are six underground stations with twenty-two 14-inch centrifugal pumps and a 7-inch stand-by which are used only when the Seine rises. When this happens the pumps take water from the sewerage system and discharge it into the Seine in order to maintain a safe level in the network. These units can handle a maximum of 212 cubic feet of water per second.

Serving the trunk lines are secondary works consisting of branches and feeders and having sumps from 2 to 4 feet wide. Waste from each house flows into a feeder through a special connection 6 feet high and 3 feet wide. From there, a branch, which usually serves 15 to 20 streets, discharges into the main conduit. Streets that are not more than 60 feet wide have one feeder, broader ones have two, one under each sidewalk.

From the beginning it was realized that it would be advantageous to provide large-size galleries that would not clog up readily and would be easy to maintain. This has proved to be correct, and has also made it possible to lay water



GROUTING

Here voids in the formation outside the tunnel lining are being filled with slurry of cement and water.

and gas pipes, telephone and telegraph cables, compressed-air lines, a pneumatic-tube system, and other utilities in the sewers where they are within reach for servicing or repairs, thus eliminating the need of digging up streets. For safety reasons, gas lines and power cables are always buried outside of, never run through, the conduits.

The total length of the network is approximately 860 miles made up of 67 miles of trunk lines and 793 miles of secondary works. More than 61,000 buildings are connected to the system, which can be entered through 15,722 manholes. In addition, there are in excess of 310 miles of accessory galleries that were cut to facilitate maintenance and repair. Normally, 35,300,000 cubic feet of water (264,750,000 gallons) passes through the sewers daily.

In general, the trunk lines have a slope of 1 to 4 feet per mile and the water flows at a rate of 2-3 feet per second. However, despite this speed and frequent sluicing, the sewers would become blocked if they were not scraped periodically. In the case of the main conduits this is done by dredging machines, while manual labor is used for the smaller ones. More than 5000 water tanks are installed throughout Paris to flush the whole network at frequent intervals. Besides the aforementioned manholes there are 24,768 openings through which fresh air is continually circulated, keeping the atmosphere throughout the entire system wholesome and free from odors. The city is justly proud of the installation and permits people to go through one of the trunk sewers in little boats designed for the purpose.

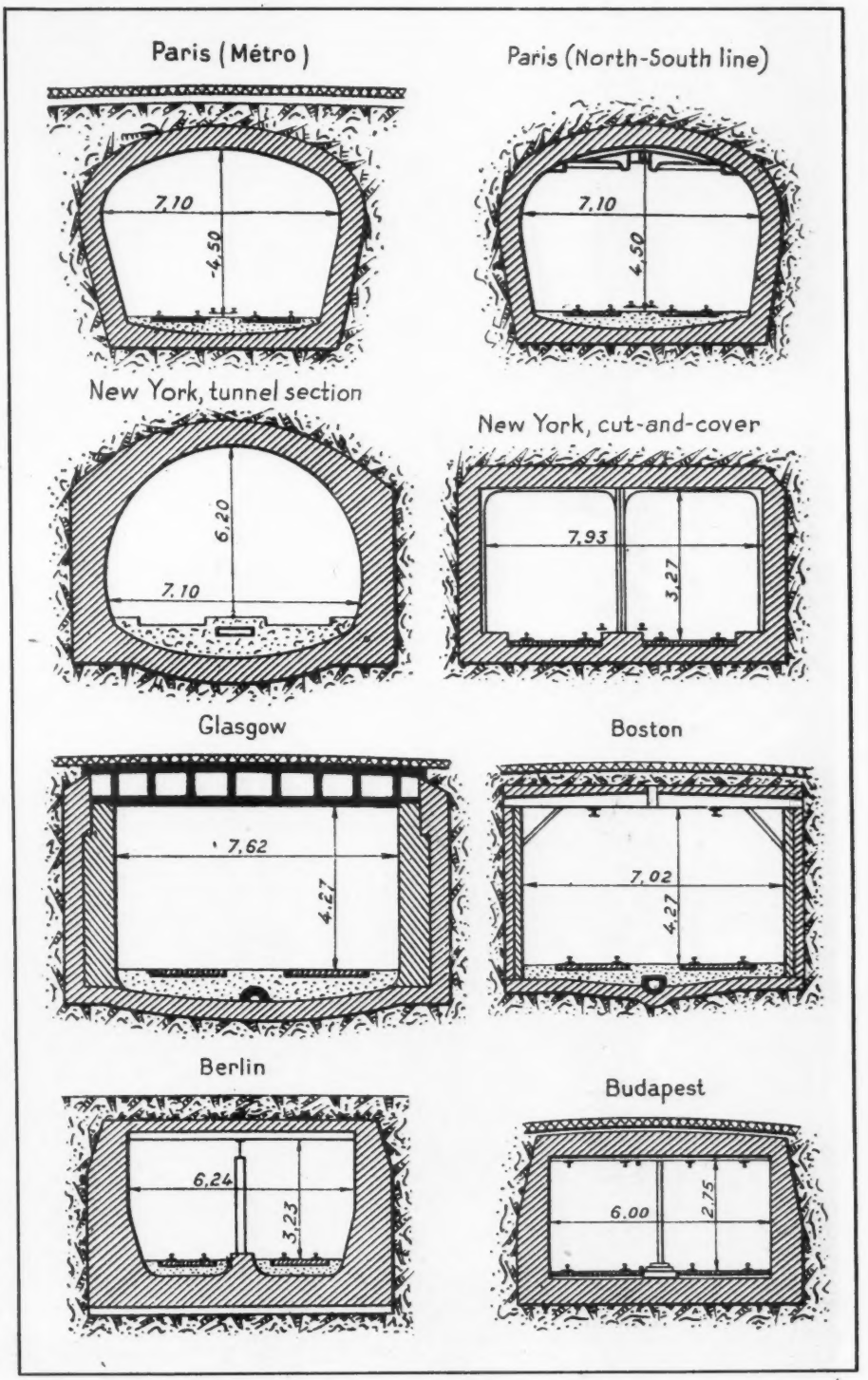
Metropolitan Railways

While London and Berlin already had their metropolitan railways in 1863 and 1875, respectively, Paris had to wait until 1900 to inaugurate her first subway despite the fact that her population had increased from 548,000 in 1789 to 1,696,000 in 1860. (New York City's first subway was opened in 1904.) The transportation problem was acute in the middle of the nineteenth century, and something had to be done about it. But the oldest plan submitted by Brame and Flachat in 1855 was intended to carry only goods from the country to the city's central market, no passengers.

Numerous projects were proposed, including an aerial railway powered by steam locomotives. Matters were complicated by rival plans offered by the state and the city. The former was in favor of connecting the six railway stations on the outskirts of Paris with the heart of the metropolis. The other wanted a system independent of the existing railroads—one based solely on Parisians' needs. Finally, after more than 30 years of disputation, the city won. In 1898 work on a 6-line electrically operated subway was undertaken, and the first line, crossing Paris from east to west at its widest point, was inaugurated in 1900.

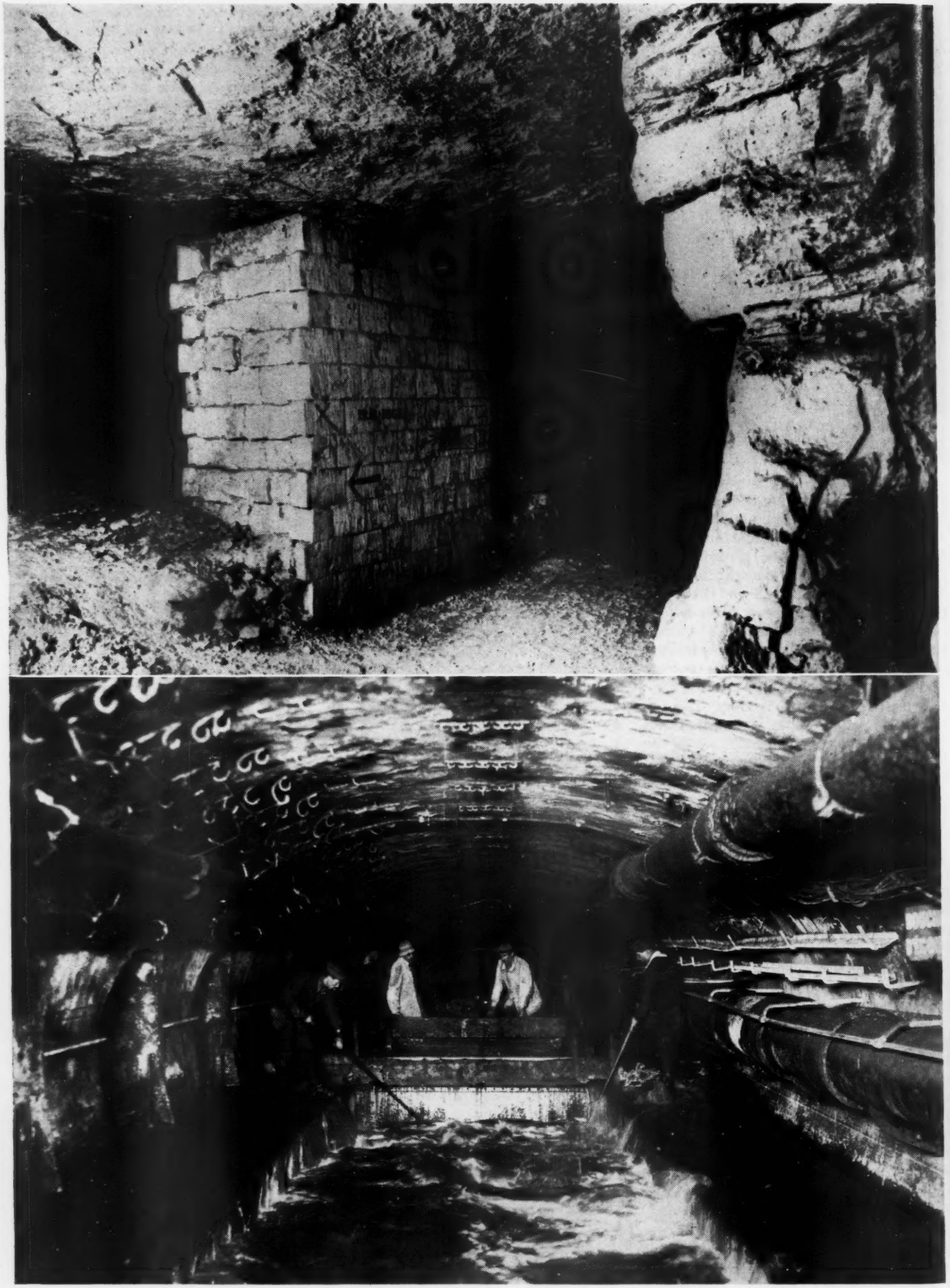
At present the Metro, as Parisians call their Metropolitain Railways, runs underground for 94 percent of its length and over viaducts for 6 percent. The tunnels are horseshoe shape in section and 21½ feet wide and 16 feet high, maximum. Nearly all are double-tracked, and rails are of standard gauge. The stations are 1500 to 1800 feet apart and vary from 225 to 315 feet in length and 126 to 144 feet in width. Except at a few points where insufficient depth necessitated the construction of a flat metallic roof, most of them are arched.

Two methods were used to build the Metro. The shield method by which a huge metallic cylinder, having the same diameter as the proposed tunnel, was pushed through the earth by means of horizontal pneumatic or hydraulic jacks. As the shield advanced, a cast-iron lining in the form of successive rings, each con-



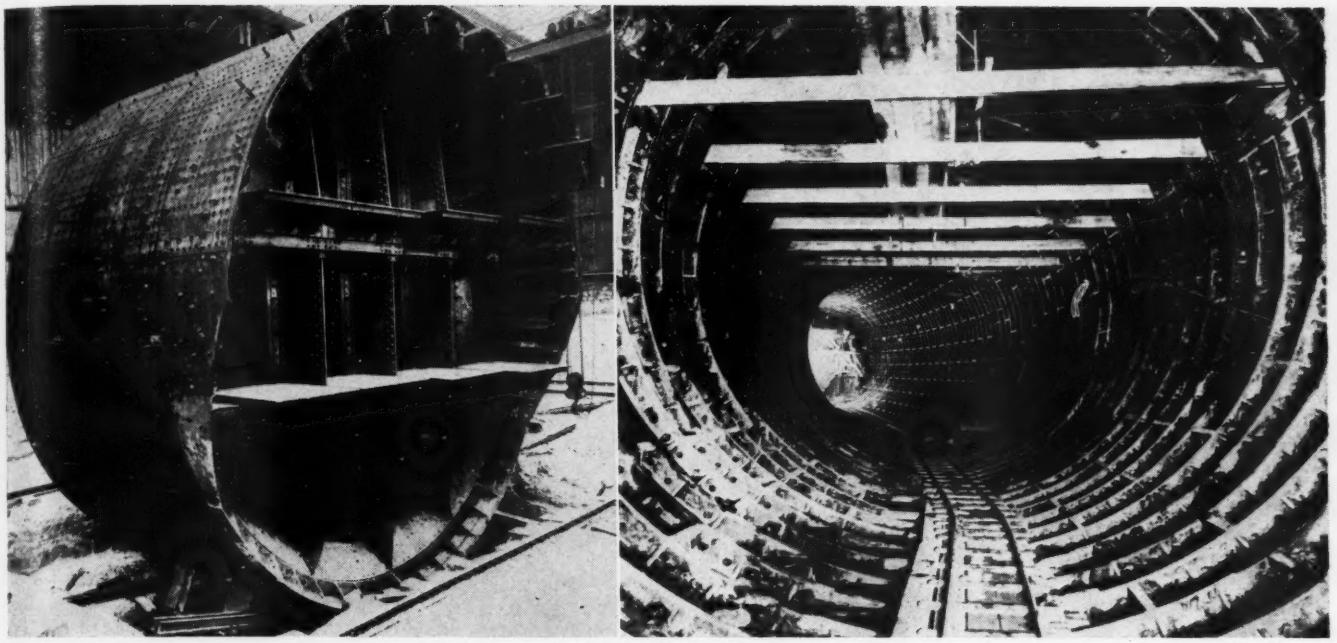
COMPARISON OF SUBWAYS

Typical sections of underground rapid-transit structures in various prominent cities. The figures are in meters.



FORMER QUARRY AND LARGE SEWER

At the top is part of an old limestone quarry in subterranean Paris showing a support built of stone blocks to prevent the roof from caving in. Pictured at the bottom is a dredging boat cleaning one of the large sewers.



SHIELD-DRIVEN TUNNEL

At the left is the skeleton of a shield that was used to drive some of the first sections of the Paris underground railway. When in action, it was fitted with jacks to push it through the ground and with other special equipment. Cast-iron rings were erected in segments behind the shield, bolted together and calked to form a watertight lining or tube (right).

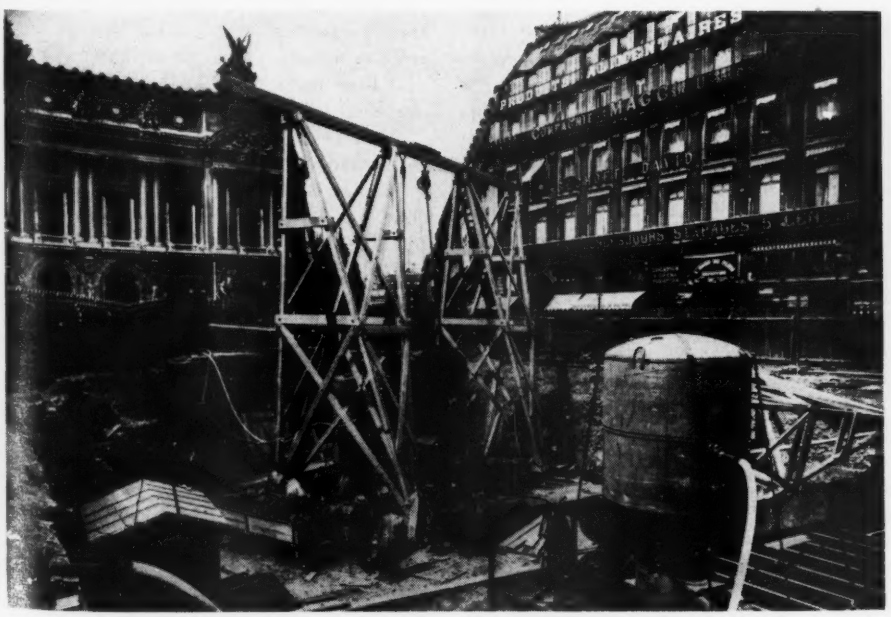
sisting of several arc segments, was erected inside the protective covering at its rear end. The latest ring put in place served as a bearing surface for the jacks to make another forward shove. This rather costly and complicated procedure was used only in unstable or water-bearing ground and where the subway was carried under the River Seine. Because the joints in the lining were calked, the tubes exclude water and insure operating safety.

Elsewhere shafts were sunk to the proposed tunnel line and a timbered pilot heading driven. The latter was of trapezoidal section 5 feet wide at the top, 6 feet wide at the bottom and 7 feet high. The floor of the heading was on the same level as the springing line of the arch. From this top bench the arch was excavated and lined with stone before work on the lower part of the bore was begun. To avoid caving, the operations were done in discontinuous sections. As the material penetrated was rather soft, most of the work was done by hand. After grouting, to fill voids in the ground surrounding the tunnel area, the side walls and invert were covered with concrete, often by pneumatic means, to thicknesses ranging from 2 to 2½ feet in the first case and 1¾ feet in the second. Station roofs and side walls were lined with white ceramic tiles.

From 19 miles in 1905, the railway system reached a length of 100 miles in 1948, not counting 12 miles of various accessory tunnels (car sidings and the like), and in 45 years the annual traffic mounted from 172 million to 1400 million persons served by fifteen lines and 280 stations. The Metro crosses the River Seine at eight different places. At five of these it goes underneath through tubes and at the three others over bridges. No two lines in the entire network intersect on the same level, and at certain points such as the Place de la Republique lines cross one another even on three levels.

Each train is made up of five 40-foot-long cars, the first and last of which are equipped with four 175-hp electric motors. Power is delivered through a conductor rail. At peak hours, intervals between trains vary from 1 minute 45 seconds to 2 minutes 30 seconds and up to 600,000 passengers are transported at the same time. Crossings and movement to and from platforms are by stairs, traveling trackways and elevators, depending upon the depth and distance. The fare is the same whatever the mileage. Ventilation is effected by the trains themselves acting like pistons drawing fresh air in and exhausting vitiated air into the atmosphere through special openings. Certain lines are provided with ventilating units.

(To be concluded)



STATION CONSTRUCTION

Excavating for a subway entrance at Place de l'Opera. A surface view of this and a companion structure is shown on Page 273.

LIFE-GIVING STREAM

The essence of reclamation is "the bringing of water to good land that has never had enough of it. Man, land, and water, together, are the means to creation of agricultural wealth." Shown is a section of the West Canal on the Columbia Basin project near Winchester in Washington State.

Lining Irrigation Canals

Bureau of Reclamation Engineers Have Developed Several Successful Low-cost Methods

Allen S. Park

IN THE semiarid West, irrigation canals are vitally important to crop growth, and water is such a valuable commodity that it pays in many instances to line them. This is an expensive procedure, however, and it is therefore important that no more money be spent for the purpose than is necessary to do a satisfactory job. In order to determine the relative cost of the various linings that have been developed, and to evaluate the worth of each type, the U. S. Bureau of Reclamation began a study of the entire subject in 1946 primarily to ascertain how costs could be reduced. A report of the investigation is now at hand.*

Figures based on records obtained from 46 Bureau irrigation projects indicate that approximately 3,900,000 acre-feet of the 15,650,000 acre-feet of water supplied them in 1949 was lost through seepage from unlined canals and laterals. Because the loss amounted roughly to one-fourth of all the available water, it follows that that proportion of the money spent on storage basins and canals served no useful purpose in that year; in other words, they could be only 75 percent efficient under the prevailing conditions.

Lining reservoirs and canals will reduce their construction costs because, with less water lost, they need not be so large as when unlined. Moreover, if all the water that is now wasted each year could be saved and used, it would irrigate approximately one million acres of land. Some of the water that seeps out collects in lower lands and renders them boggy and unfit for cultivation, thus causing further loss of revenue. Linings not only eliminate this but also reduce operating and maintenance charges, increase the carrying capacity of canals by accelerating the rate of flow, and extend their service life.

In nearly all instances, then, it is desirable to line the channels, but from an economic standpoint it is justifiable only when the value of the benefits exceeds the lining costs, or where the safety of a canal is at stake. That might be the case where a ditch passes through filled ground, where it is dug partly in earth and partly in rock, or where it is exposed to the attack of burrowing animals that may damage it to the point of failure.

During its investigations, which covered a period of 5½ years, the Bureau placed 24 million square yards of lining in 611 miles of canals, some newly built and some already in existence. The total was made up of approximately eighteen million square yards of unreinforced-concrete and mortar linings, two million square yards of asphaltic types, and four million square yards of earth-material linings.

As a result of these operations, it is estimated that 706,000 acre-feet of water, valued at $1,609,000, is saved annually; that yearly maintenance costs are cut by $660,000; that about 5900 acres of waterlogged land, worth $1,345,000, was reclaimed; and that miscellaneous savings of $380,000 were accounted for. In the last-mentioned category are included reduced expenditures attributable to the elimination of drains, less excavating required for a lined canal, and prevention of slides caused by water-logged sloping ground.

Bureau workers have found several ways to lower lining costs. By liberalizing and simplifying specifications covering line, grade and finish of hard-surface linings they have encouraged greater mechanization, with attendant faster work. Except where safety calls for it, reinforcing steel is no longer demanded

*"Canal Linings and Methods of Reducing Costs," for sale by Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price, 25 cents.

PREPARING SUBGRADE

A firm foundation is required if any lining is to be successful. To prepare the subgrade economically, a plow-type ditcher has been developed. It is pulled by a tractor and is adjustable for various canal widths and depths.

for concrete and mortar linings, with resultant savings of 10 to 15 percent. New facilities, known as subgrade-guided slip-forms, are now utilized for placing both concrete and asphaltic linings and have cut costs so much that it is economically feasible for the first time to line small canals and laterals. And through the adaptation of the construction industry's large earth-moving equipment the use of thick (6 to 8 feet) compacted linings of selected earth is on the increase. On large jobs, where suitable material is available, this type is one of the least expensive to apply. Standardization of canal shapes and sizes and the development of a new lining consisting of an asphalt membrane covered with a protective blanket of earth have also contributed to the success of the lower-cost movement.

Proof that the Bureau's efforts have borne fruit is found in bid prices on contracts and records of actual jobs over the period under consideration. In 1946, contractors commonly bid $3 per square yard for a 3- to 4-inch reinforced-concrete lining. In 1949 and 1950, the figure for unreinforced concrete of the same thickness was generally around $2.20 per square yard, and government forces actually placed some 3-inch linings in small laterals and farm ditches for as little as $1.13 per square yard.

An ideal canal lining should be watertight, of moderate cost, resistant to the growth of weeds and the attack of burrowing animals, strong and durable and permit construction in a shape and finish insuring maximum hydraulic efficiency. No single known material has all these properties, but each one possesses most of them to some extent. The choice depends upon the conditions encountered in each case.

As already indicated, concrete or mortar is used for the most part because it requires little maintenance, stands up well, and satisfactorily carries water at high velocity. When reinforced concrete was in vogue, mechanized equipment for trimming the subgrade and placing the lining ran on rails laid on the canal berms or banks. The high cost of rails was one of the reasons why the study of unreinforced linings was undertaken. With the adoption of the latter, preparation of the subgrade became important, because an unstable foundation will settle and cause the concrete to crack. Excavation of and final preparatory work on the subgrade is now usually done by special ditchers pulled by tractor and adjustable for canals of varying depth and width.

The subgrade-guided slip-form mentioned earlier is similar to a unit that originated on the Bureau's Umatilla project in 1915 but saw little service thereafter. Clyde E. Shields of the Bureau's Gila project revived and improved it in 1946, and it functioned so well for lining small ditches that the idea was adopted by equipment manufacturers, contractors, and Bureau forces.

The form is towed by a tractor fitted with a side boom and traveling on one bank. The forward section is shaped in accordance with the contour of the subgrade and does the guiding; rearward is the slip-form proper, shaped to conform to the finished lining surface. Between the two is a compartmented trough which holds concrete and distributes it uniformly. A trial on the Gila Canal indicated that best progress was made (4000 square yards per day) when the material was delivered by traveling plant mixers. Concrete linings now range from 2 to 4½ inches in thickness, depending upon the size of the canal.

One concrete or mortar lining is composed of shotcrete, a mixture of selected sand, portland cement and water that is sprayed on to the subgrade by means of a nozzle and compressed air. The maximum size of the sand particles is about 3/16 inch, and because of the absence of large aggregate, a greater proportion of cement is required than in concrete.

The shotcrete process may be used to line canals of any size and to any thickness. It is especially advantageous where

APPLYING SHOTCRETE

A mixture of cement and sand is borne by air to the nozzle and there joined by water carried in a second hose. The nozzle is held 3 or more feet from the surface being coated. This type of lining gives good service when applied in thicknesses of 1½ inches or greater. Shotcrete is also widely used for repairing other kinds of hard-surface linings.

ASPHALT LININGS

A membrane of asphalt about ¼ inch thick makes a good lining when protected by a layer of earth or gravel. It is applied at about 400°F by spray bars (left). Sometimes the membrane is prefabricated and laid in strips, which are then cemented and covered. Those shown below consist of asphalt sprayed on fiber glass and are only ⅛ inch thick.

the subgrade is irregular, as in rock cuts. It can likewise be applied without difficulty around projecting structures, whereas in the case of concrete placed by slip-form, sections several feet wide on both sides of such obstructions must be lined by hand. In addition, shotcrete is highly satisfactory for resurfacing cracked and leaky areas in a concrete lining. Because little equipment is needed and it is extremely mobile, the method is favored for small and widely scattered jobs, especially for lining laterals and farm ditches with sharp curves and numerous structures.

Apparatus for mixing and applying the material has been developed by several manufacturers, and trade names such as "Gunite" and "Jetcrete" have been given to the mortar. The mechanism includes a series of air locks from which premixed dry sand and cement is fed into a flexible hose through which it is forced to the nozzle by air pressure. Water is pumped through a second hose and added to the mix at the nozzle. The latter is held perpendicular to the surface being coated and about 3 feet away from it.

By making repeated "passes" the operator builds up the material, and the pressure consolidates it. Shotcrete linings are not so thick as those of concrete. Some of only 1 inch have withstood twenty years of service in canals of the Salt River Valley of Arizona where conditions are unusually favorable. Normally, however, the Bureau of Reclamation does not place any less than 1½ inches thick. The Southern California Edison Company has used shotcrete for a long time for lining power canals in the Sierra Nevada Mountains, where extremes of temperature occur.

In general, it has been the Bureau's experience that such linings will give good service for twenty years or more, and in the Icicle Irrigation District, in Washington State, a 1½-inch reinforced lining of this kind dating from 1924 is said to be in good condition. The cost of shotcrete varies with the thickness, extent of the job, availability of materials and other factors, but for 1½-inch unreinforced linings it has ranged from $2.39 to $3.05 a square yard on Bureau operations since World War II.

One of the Bureau's regional offices tried out some twenty different materials and methods for repairing cracked or otherwise damaged linings and reported shotcrete to be the most satisfactory among them. About 500 square yards of the material, ½ inch thick, was placed at reasonable cost in restoring the worn concrete lining of the 37-year-old Ridenbaugh Canal.

The Bureau program included the investigation and application of asphaltic linings. Two types—asphaltic concrete and buried asphalt membranes—were found to be economical and serviceable. Asphaltic concrete is hot-mixed asphalt-cement and aggregate such as has long been used for paving streets. Asphalt-cement is defined as a "semisolid asphalt obtained by the removal of the volatile materials, lighter oils, and all but a small fraction of the heavier oils from crude petroleum."

Asphaltic concrete can be placed by either the inexpensive subgrade-guided slip-forms or the heavier rail-borne equipment with which reinforced-concrete linings are applied and is suitable for both small and large canals. It is generally mixed at a temperature of around 325°F in batches of 1000 to 2000 pounds that are delivered by dump trucks. To compact the material and thus impart the desired surface, a weighted ironing plate is passed over it as a final operation.

Because asphaltic concrete is plastic, some varieties of weeds will penetrate it; in fact, plant growth is promoted by the heat absorbed by the black surface and transferred to the ground underneath. To discourage this, and especially where a lining covers areas in which vegetation such as tules, cattails and willows are firmly rooted, the subgrade is treated with a soil sterilizing agent. This adds about ten cents a square yard to the cost.

The first extensive use of asphaltic concrete was made in 1947 in the Pasco lateral system, in the State of Washington. A 2-inch layer was placed on 88,160 square yards of surface for $2.49 per square yard, including trimming of the subgrade. In the following year, the Ygnacio Canal, near Concord, Calif., was similarly lined at a cost of $2.71 per square yard, which also covered sterilizing the soil because the route passed through orchard land and many tree roots remained in the ground after the canal was excavated.

A buried asphalt-membrane lining consists of a thin sheet of asphalt-cement that is sprayed on the surface and covered with earth or gravel. Experiments were conducted with a membrane alone, but it was found that it needed protection from the sun's rays and from mechanical injury from the hoofs of cat-

SAMPLE SEAL COATS

To determine the best seal coat for asphaltic canal linings, 24 test panels of different materials of this kind were applied in varying thicknesses to the 3-year-old asphaltic-concrete lining of a canal on the Boise, Idaho, project. They were inspected and reported on each year. The picture shows fine sand being blasted onto one of the panels with compressed air to help keep the covering in place when warmed by the hot summer sun.

tle and the like. The top layer or mantle is usually about 12 inches thick, and the canal is overexcavated to that extent. Unless it is too sandy, the soil removed from the ditch serves the purpose. Where the rate of water flow is greater than 1½ feet per second, a gravel blanket from 3 to 6 inches thick is applied.

Following a period of experimentation, the asphalt-membrane lining became popular as a low-cost means of seepage control. Beginning in 1948 on the Klamath project, in Oregon, a total of 1,750,000 square yards has been placed on 80 miles of canals. Contractors have been paid from 82 cents to $1.71 per square yard. A fair cost range at present is 75 cents to $1.00.

To obviate the need of heating the asphalt in the field in order to spray it, which is uneconomical on small jobs, prefabricated membranes were designed and are now used extensively. One kind is made by catalytically blowing a 3/16-inch layer of asphalt on heavy kraft paper. The lining comes in strips 3 feet wide and 36 feet long, is shipped in rolls and laid on the subgrade either longitudinally or transversely. Joints are lapped 2 inches and cemented with asphalt, after which the membrane is covered with earth. In time, the paper backing disintegrates.

Another type is reinforced with a thin mat of glass fibers and the asphalt film is only ⅛ inch thick. The result is a material that is lighter than the paper-backed membrane and cheaper to ship. The fiber glass increases the membrane's strength but adds to the cost, which runs around 50 cents per square yard, as compared with 30 cents for the heavier variety. Other asphaltic seepage-stopers include pneumatically applied asphalt-sand mixes, and grouting with asphalt under pressure also has been tried.

Where suitable earth materials are available they can sometimes be used successfully to line canals, but they must generally contain a percentage of impervious soil. Such a lining may be compacted into a 6- to 12-inch layer and covered with a blanket of coarse soil or gravel of equal or greater thickness, according to conditions. In some instances, selected materials spread loosely (uncompacted) on the bottom and slopes of a canal may serve the purpose. This is true where the subsurface has voids, which are thus plugged and made watertight by the lining.

Clays such as bentonite which swell when wetted also are effective seepage controllers and are economical if they can be obtained near at hand. Soils stabilized by the addition of resins and chemicals likewise may come into use as linings when more is known about them. The same can be said for soil-cement, with which the Bureau has already had considerable experience.

Under the heading of miscellaneous linings with which the Bureau has concerned itself are shotcrete on an asphaltic membrane and synthetic plastics. Shotcrete applied to an impervious membrane provides a satisfactory lining of inappreciable thickness. It is suitable for use in rock cuts where it is desirable, in the interest of economy, to keep excavation down to a minimum. In such areas the thickness of the shotcrete is held to around ¾ inch.

Several manufacturers are coöperating with the Bureau in research work on plastic linings. One of the promising materials is polyethylene made in sheets from 1 to 5 feet wide and from one to ten thousandths of an inch thick. It resists both rupture and rot well, but so far the investigators have found nothing to which it can be permanently bonded—the question as to how to hold it in place has not been answered.

Old and cracked hard-surface linings are being repaired by undersealing with asphalt, a process similar to that of mud-jacking sunken highways and airplane runway strips. Holes are drilled in the affected area in a regular pattern, usually on 6- to 8-foot centers, and into these, in turn, is pumped hot asphalt-cement. The purpose is to fill the watercourses that have found their way under the lining and to leave an impermeable layer of asphalt between it and the subgrade to prevent further seepage.

SEALING CRACKS

In 1946 the U.S. Bureau of Reclamation developed a plasticized asphaltic material that is applied cold to fill cracks in concrete linings, to which it adheres well. The picture shows it being tried out on the Yakima Ridge Canal in the State of Washington. The air-operated gun was designed by members of the Bureau's staff.

Aluminum Venture in British Columbia

Heavy Rock Excavation in Powerhouse Area and Problems of Building Transmission Line Through Rugged Terrain

H. R. Rice

OFFICIALS ON VISIT

Left to right: R. E. Powell, president of Aluminum Company of Canada Ltd., which is carrying out the huge construction job; P. E. Radley, manager of the project, with headquarters in Vancouver; N. V. Davis, president, and McNeeley DuBose, vice-president of Aluminium Limited, parent concern of the Canadian aluminum interests. In a paper written by two engineers connected with the undertaking it is stated that "the whole development is a tribute to the vision and work of Mr. DuBose." The picture was taken during a visit of the party to Kitimat in August, 1951.

UNIT PENSTOCK HEADING

Tunnels for the penstocks leading to individual turbines are each 9 feet in diameter and of circular section. Here a crew is shown drilling with two boom-mounted drifters on a carriage on caterpillar treads. A round consisted of 28-30 holes 7 feet deep.

ANGLER'S DELIGHT

They don't toil all the time at Kitimat. A member of a tugboat crew posing with a 46½-pound spring salmon taken in Tarte Bay.

Part 3

IN DECIDING to locate the powerhouse underground, the designers were far from setting a precedent, except for the size of the opening involved. Approximately 75 such plants are in operation or under construction in various parts of the globe. The idea was obtained from a Canadian hydroelectric station built at Niagara Falls in 1895 with its turbines in a pit and connected by vertical shafts 140 feet long with their generators on the surface.

Three years later, at Snoqualmie Falls, Wash., the turbine, generator and control board of a 10,000-hp plant that operates under a head of 270 feet were located in a chamber 200 feet long, 40 feet wide and 30 feet high excavated in basaltic rock. The powerhouse is reported to be still functioning successfully. Since then similar plants have been constructed in areas ranging from southern Italy to well within the Arctic Circle and with operating heads of from 17.17 feet at Friedigen, Germany, to 3540 feet at Tyin, Norway. The chambers have been hollowed out of various kinds of rock of igneous, sedimentary and metamorphic origin.

The original Snoqualmie station was put underground to escape excessive spray and ice from nearby falls. Nowadays there are often numerous reasons for putting the generating equipment under cover. Probably the first one that occurs to most persons is protection from enemy bombing in the event of war. Given sound enclosing rock, however, there are various other advantages, and it was mainly in consideration of them that the Kemano designers elected to place not only the generating station un-

CAMP AT KEMANO

This is Morrison-Knudsen's largest base of construction operations. Buildings of the quonset type serve as shops and warehouses and are used for other similar purposes. A concrete mixing plant can turn out 60 cubic yards per hour. The 200x40-foot mess hall is reported to be the largest in British Columbia, but it takes three sittings each meal to accommodate the 1800 boarders. The camp's movie theater is open pretty much around the clock, and admission is free. A modern hospital staffed by a doctor and four nurses has been provided, and the Royal Bank of Canada has established a branch at Kemano. A 10-mile highway extends from Kemano Bay, which is now a weekly port of call for boats from Vancouver, 510 water miles southward.

derneath the surface but also the penstocks that will deliver falling water to it.

The chief reasons outlined are as follows: Where penstocks for high-head operation are encased in good rock that will help to withstand the pressure, the wall thickness can be safely reduced and a material saving made in steel. In this instance, the steel liner of each conduit will have a wall thickness of from 9/16 inch at the upper end to 1 5/16 inches at a point 150 feet upstream from where the lower end branches into 11-foot lines leading to the turbines. Just above the wye, the thickness will be 2½ inches.

Before designing the pressure conduit system, Alcan engineers studied similar installations operating under high heads in Switzerland, France, Italy, Norway and elsewhere. They also had the counsel of Dr. Arnold Kaech, who engineered several of the high-head plants in Europe. We have already told how the strength of the enclosing rock was investigated by lodging a 10-foot sphere deep within the mountain mass and subjecting it to a pressure three times as great as that to which the conduits will be exposed. In addition, special tests were made to prove the effectiveness of the methods that had been decided upon for fabricating and joining the sections of liner pipe.

Where penstocks are exposed, massive supports and anchorages are required to hold them securely. Unless there are protective trees, they are liable to be damaged by snow and rock slides, and even where there is good timber cover it may be destroyed by fire. Under rigorous winter conditions, such as prevail at Kemano, it would be practically impossible to construct penstocks in the open, but tunneling within the mountainside can go on without interruption throughout the year. In an underground powerhouse in rock, foundation troubles disappear and a minimum of concrete is needed. Structural maintenance work and expense on both penstocks and power plant are virtually eliminated and working conditions for the operating personnel are equable.

Against these advantages is placed the obviously greater construction cost involved in hewing the extensive openings out of solid rock. This factor was carefully weighed, and it might have resulted in the abandonment of the underground scheme if it had been undertaken even a decade ago. However, engineering studies brought out the fact that marked advances have been made since World War II in the technique of excavating rock, with corresponding reductions in costs. Mentioned particularly among them was the development of detachable drilling bits with tungsten-carbide inserts.

The Kemano station will ultimately house sixteen turbines. Each will be of the vertical, single-runner, 4-nozzle impulse type rated at 140,000 to 150,000 hp at 327 rpm and direct-connected to a vertical 3-phase, 60-cycle, 13,800-volt generator rated at 106,000 kva at 140°F temperature rise to 122,000 kva at 176°F.

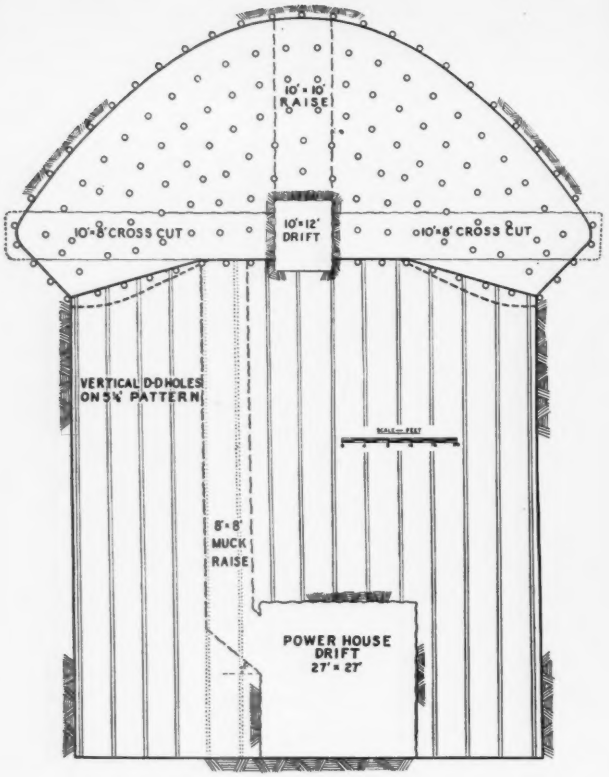
The transformers will be situated inside the powerhouse on the downstream side of the generators, and each pair of the latter will feed into a bank of three single-phase, 71,000-89,000 kva transformers rated at 301 kv. Their output will be delivered to a surface switchyard through power cables carried on racks in a tunnel designed exclusively for this purpose.

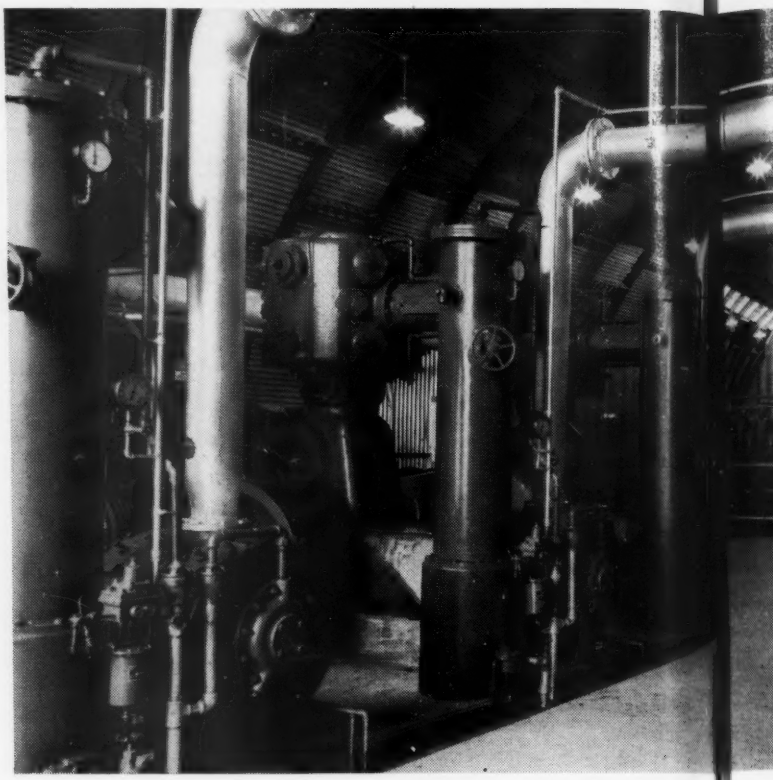
The chief features of the power-plant area, going upstream, will be: 1, main tailrace tunnel; 2, main tailrace branches and drainage tunnel from and to the valve chamber; 3, powerhouse excavation; 4, valve chamber; 5, construction access tunnel (the latter is coursed through the main tailrace, No. 4 unit tailrace, power-plant drift and penstock wye branches); 6, penstock wye branches; 7, unit tailraces; 8, unit penstocks; 9, penstock wye branches; and 10, permanent access tunnel.

To accommodate the sixteen generators, the main underground chamber will ultimately have a length of 1100 feet, of which 700 feet is now being completed to house the eight units to be fed by Power Tunnel No. 1. As already mentioned, three machines are expected to be placed in service around March, 1954.

Powerhouse Excavation

This phase of the operations was divided into two stages: the excavation of the arch and of the main body of the underground chamber. The general method by which the work was conducted is illustrated in an accompanying drawing of a cross section at one of the slots that are dealt with later. Extending the full 700-foot length of the powerhouse, a 27x27-foot drift was driven on the main floor level. Drilling was done from a 3-deck jumbo installed on a 11-cubic-yard diesel dump truck and carrying eight 3½-inch Ingersoll-Rand DA-35 drifters —six on columns and arms and two on the top deck on booms. The drilling pattern for this drift, which is the same as that for the main permanent access tunnel, the construction access tunnel and the main tailrace tunnel, is shown in an accompanying sketch. All these bores were excavated with equipment of the same kind. Muck was handled by a 1½-cubic-yard electric shovel and was loaded into 6- and 11-cubic-yard dump trucks. A 20-man drilling crew and a clearing crew worked in each heading on each 8-hour shift.





HOW POWERHOUSE CHAMBER WAS EXCAVATED

This drawing represents a section through the powerhouse chamber at one of the seven transverse slots cut in the arch section to facilitate its removal. The 120-foot block of rock between each adjacent pair of slots was drilled from each side with 141 diamond-drill holes spaced as indicated and 55 feet deep. Muck from blasts was chuted down to the power-plant drift into trucks. After the arch had been excavated, the bench was removed by putting down vertical diamond-drill holes, as shown.

Arch Section

At the spring-line elevation of the arch section, and 71.75 feet above the main power-plant floor level, a 10x12-foot drift was driven the entire length of the excavation. Access to this drift was gained through the exploratory adit previously mentioned and also through a manway raise from the main 27x27-foot powerhouse drift. Along the central 10x12-foot drift was then laid out a series of transverse slots, each 10-feet wide and parallel to the cross section illustrated on this page. There were seven of them, the first one being at the extreme north end of the excavation and the others spaced on 120-foot centers southward.

Slightly to one side of each slot section an 8x8-foot raise was driven vertically from the 27x27-foot drift for chuting muck from the arch section to trucks spotted on the main floor level below. These chute raises were excavated with two Canadian Ingersoll-Rand CR-58 stopers, using Carset (tungsten-carbide insert) detachable drill bits. Starting bits were of 1¾-inch gauge, and a reduction of 1/32-inch was made with each change. A round consisted of 24 holes, each 7 feet long.

From the subdrift on the spring-line level 10x8-foot crosscuts were advanced to each side of the arch to provide breaking faces for cutting the slots. The crosscuts were excavated by means of drills mounted on Jacklegs, extensions being added when working on the upper parts of the faces. From the central subdrift in each slot a 10x10-foot vertical raise was driven to the top of the arch. Each such raise and crosscut established the plane of that particular slot.

Each slot was then excavated by breasting with diamond-drill holes from the center raise, putting in flat holes to points 2 feet beyond the neat lines of the arch in order to insure ample room for the drills in the subsequent mining of the body of the arch. No standard pattern was followed in the case of the breast holes; they were generally drilled in horizontal rows of three each with 4 feet of burden between the rows. After blasting, the slots were cleared of muck by means of 50-hp electric slusher hoists which dumped their loads into the chute raises.

The block of ground between each pair of transverse slots was removed by drilling 55-foot diamond-drill holes from each slot toward the center of the block, the round consisting of 141 holes. Each slot-to-slot section contained some 15,510 feet of holes, or about 1.23 feet per cubic yard of rock. They were loaded to within 12 to 15 feet of their collars and blasted with short-period electric caps in such a way as to shrink to the central subdrift. Holes were 1 31/64 inches in diameter, and the bits were of the sintered-set borts type. Both coring and noncoring bits were used.

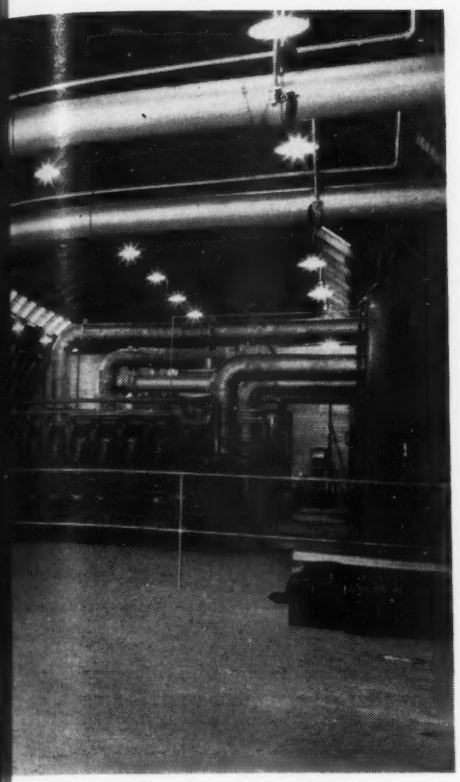
Before excavating the main body below the spring line, the arch over the first three slots was completed and the permanent concrete roof placed. This lining is approximately 2½ feet thick at the top of the arch and 5 feet thick near the spring line, or a total of about 23.5 cubic yards per lineal foot. As areas of weak ground were met near the principal jointing planes and watercourses, they were supported with roof bolts. These proved very satisfactory, and were also used extensively where temporary support was required until concrete could be placed.

Body of Chamber

The main body of the powerhouse chamber was excavated by drilling vertical holes on a 5½-foot pattern with diamond drills and blasting them in such a manner as to develop a longitudinal slot over the main drift, using the chute raises as initial breaking faces. The holes towards the walls were then broken to this slot, and the spoil removed mainly by 1½- and 1¼-yard electric shovels loading into 6- and 11-yard diesel-powered dump trucks. A small amount was dumped through the turbine pits into the unit tailraces.

Other Excavations

The north and south tailrace branches were driven by a 14-man crew operating a 6-drill carriage with two main platforms so that work could be carried out on three levels. These jumbos are mounted on caterpillar treads and can



KEMANO POWER SOURCE

Shown at the left are three of seven Canadian Ingersoll-Rand Type XVH, 1100-cfm air compressors powered by motors that receive current from four generators (in background) driven by diesel engines and having a combined capacity of 5000 kva. Supplementing these stationary units are eight diesel engine-powered portable machines with an aggregate capacity of 3700 cfm, bringing the total output of the Kemano compressor plant to 11,400 cfm. The air is discharged at 110 psi and piped to the various drilling locations in the network of underground powerhouse chambers and tunnels. In addition, an 8-inch line runs up the mountainside to serve the penstock and tunnel drilling crews on the 1600- and 2600-foot levels. Ventilating air for the different headings is delivered by positive-pressure-type blowers through 22-inch lines.

UNDERGROUND ROCK EXCAVATION

	Cubic Yards
Kemano powerhouse	254,158
Powerhouse level	56,648
Penstocks, etc	83,973
Main tunnels and adits	1,230,395
Total	1,625,174

1 Cubic Yard = 2.30 tons

be placed and removed by small diesel-powered tractor bulldozers. Headings were mucked by an overhead loader usually into 6-yard dump trucks.

All headings were well illuminated by floodlights, which were attached to the jumbos during the drilling operations. But prior to charging, the lights were dismounted and moved back a safe distance to prevent setting up dangerous stray currents in the steel members of the structure.

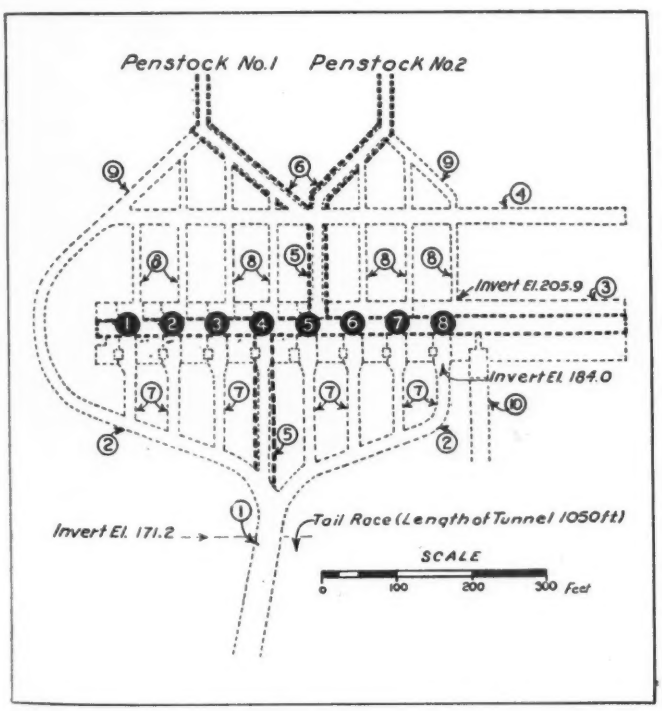
The unit penstock tunnels are circular in section and 9 feet in diameter. They are being advanced by two 3½-inch drifter drills on a small caterpillar-tread mounting. Rounds consist of 28 to 30 holes 7 feet deep, and spoil is removed by electric slushers which scrape it over portable ramps into 6-yard diesel trucks that are spotted at the lower ends of the penstocks in the main power-plant tunnel.

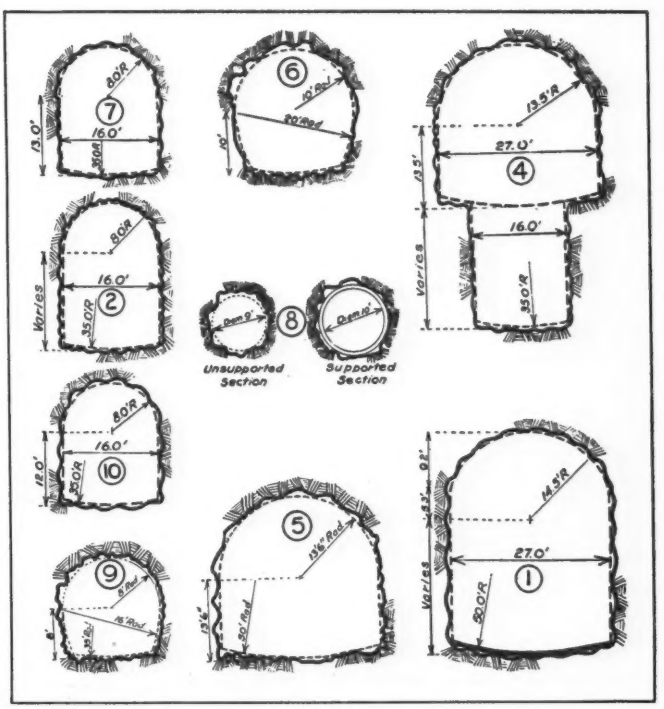
The 14-foot-diameter circular tunnel sections of the main penstocks are driven on an invert grade of 0.0025 percent for a distance of 300 feet from their bifurcations to the point where they assume a 48° slope to connect ultimately with the main power tunnel on the 2600 level. The headings are advanced from a 5-drill carriage with caterpillar treads, and a round consists of 40 holes drilled 9 feet deep. Excavated material is handled by a diesel-powered overhead loader and hauled away by 6-yard dump trucks.

Powerhouse Valve Chamber

The valve chamber of the power station will be 20 feet wide, 37 feet high, and 700 feet long. When the project was visited, the plan was to excavate its southern half full heading with a 10-machine jumbo mounted on a 11-yard truck and the remainder by a pilot tunnel benched to grade. Also still to be driven at that time was the tunnel for the conductors leading from the powerhouse transformers to the switchyard outside the portal. This bore is to be rectangular in section, 1504 feet long and 17 feet wide by 12 feet high. These measurements are inside the neat lines, or inside whatever support may be required.

Permanent access to the underground power plant will be by a tunnel 27 feet





PLAN AND CROSS SECTIONS OF OPENINGS IN THE POWERHOUSE AREA

The diagram at the left shows the general arrangement of the openings required in the immediate vicinity of the underground power station. The numbers with black backgrounds indicate the generating units for the first phase of the power development. At the right are the cross sections of the various workings, the locations of which are indicated on the plan drawing by identical numbers with white backgrounds.

TABLE OF PRINCIPAL SERVICES FOR UNDERGROUND DEVELOPMENT WORK

Camp	Accommodations Men	Compressed Air Cfm	Electric Power Kva
Kemano (main)	1,250	11,400	5,000
Kemano, 1600 level	95	from above	from above
Kemano, 2600 level	165	from above	from above
Horetzky	245	5,500	1,250
Tahtsa	260	3,300	750
		20,200	7,000

wide and approximately 1500 feet long on which excavation has been completed. Its dimensions are generally similar to those of the main tailrace tunnel, as was the method of driving.

Transmission Line

The Kemano-Kitimat transmission line has presented some of the most interesting problems of design and construction on the entire project. The only feasible route follows narrow valleys which afford but limited space for the erection of a line sufficient to carry the 1,200,000 kw of electrical energy involved.

The most difficult section from both standpoints is the 10.6-mile stretch that extends through narrow Kildala Pass at Elevation 5300, where snow may lie 20 feet or more deep during the winter months. Lack of knowledge about the effect of such factors as icing conditions and wind loadings necessitated much research work if the designers were to provide a line that would be efficient and reliable—reliability being especially vital because the aluminum reduction process is a continuous one and any interruption of power for more than a few hours would cut metal production and entail a costly loss.

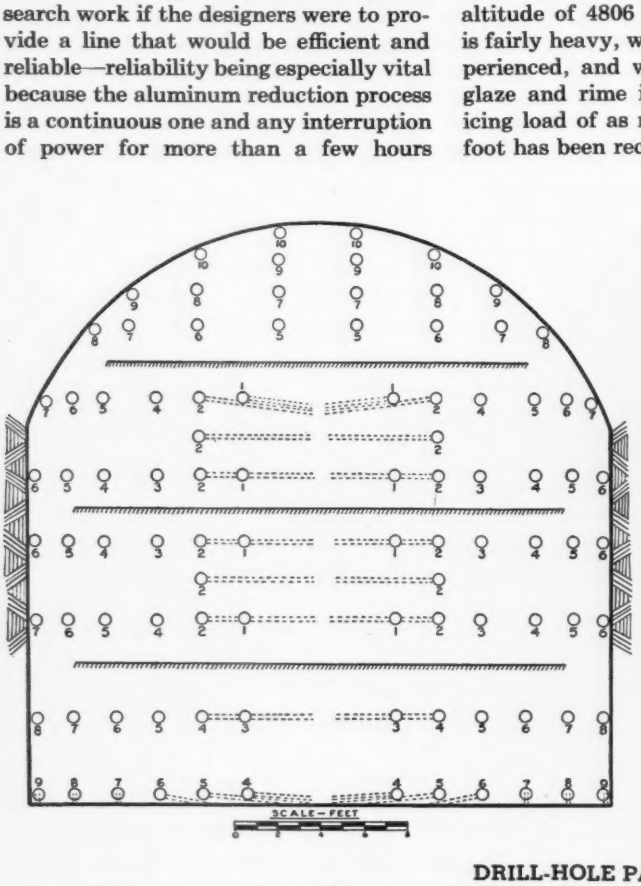
Extensive investigations were made of transmission lines and of experimental installations for the observation of icing conditions in the mountainous regions of Europe. In addition, a test span was erected on the summit of Kildala Pass some 2000 feet above timber line. Two 26-foot-high towers were built there of tubular aluminum members, which had to be transported to the site by helicopter. This experimental line was equipped with various recording instruments, and a crew of observers was stationed in cabins along the transmission route.

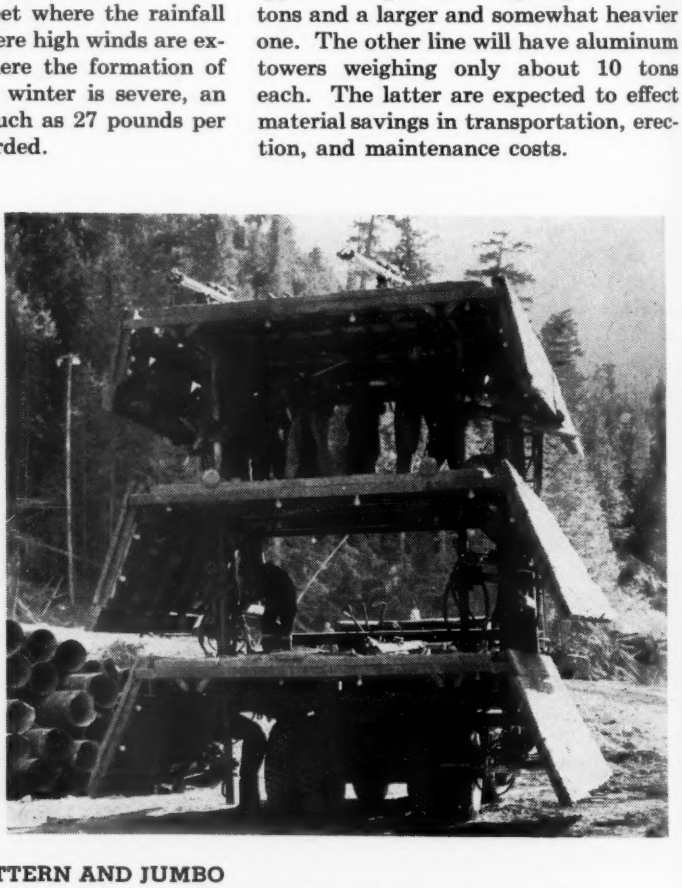
During the winter of 1950-51 the maximum ice loading of the test span was 2.4 pounds per lineal foot. Obviously, the conditions occurring during one winter are not necessarily the worst that may be encountered. For example, at Puy de Dome experimental station in south-central France, which lies at an altitude of 4806 feet where the rainfall is fairly heavy, where high winds are experienced, and where the formation of glaze and rime in winter is severe, an icing load of as much as 27 pounds per foot has been recorded.

As a result of these findings and the study of a wealth of other experimental data and observations, the double-circuit transmission lines in the Kemano and Kitimat sections, 9 and 30 miles long, respectively, have been designed for a yield-point load of 24 pounds per foot. The conductors will be of aluminum and have an outside diameter of 1.545 inches, a weight of 2.032 pounds per foot and an ultimate strength of 55,400 pounds.

For the 10.6-mile Kildala Pass section, a single-circuit line has been adopted. The conductors will be 2.295 inches in outside diameter, weigh 4.77 pounds per foot, have an ultimate strength of 135,700 pounds per foot and will be built for an icing load of 40 pounds per foot. In both cases the wind load, combined with a 2-inch radial deposit of rime on the line, has been set at 8 pounds per square foot.

The double-circuit lines will be accessible for patroling and maintenance by roads being constructed along the Kemano and Kildala valleys to switchyards, which will mark the ends of the Kildala Pass section. Part of the latter will be served by helicopter and the remainder by cableways. One of the two single-circuit lines through Kildala Pass will be supported by steel towers of two types: a light one weighing about 33 tons and a larger and somewhat heavier one. The other line will have aluminum towers weighing only about 10 tons each. The latter are expected to effect material savings in transportation, erection, and maintenance costs.





DRILL-HOLE PATTERN AND JUMBO

Drilling of the main tailrace tunnel, two access tunnels and the main drift in the powerhouse chamber was done by 3-deck carriages mounted on Euclid trucks and carrying six DA-35 power-feed drifters on columns and arms and two others on booms on the top deck. One of the jumbos is pictured with the outer sections of the decks folded down. Holes in the 94-hole drill round used in these tunnels were fired in the order indicated. The advance per round averaged 12 feet and called for about 1200 lineal feet of drilling. Consumption of explosives was approximately 3.2 pounds per cubic yard of rock broken and muck was handled by 1½-yard electric shovels.

DRILLING TAILRACE TUNNEL

Looking toward the face of the 27x27-foot bore, with a truck-mounted drill carriage at work. The structure at the right on caterpillar treads was used as a platform for trimming the roof, putting up a vent duct, etc. The line delivering air to the drills is shown at the lower right.

The towers will be anchored to rock by means of bolts as much as 9 feet long. The relatively large holes required for this purpose will be put down by conventional rock drills, probably drifters suitably mounted for vertical work. Because transportation is a problem, small compressors will be utilized even though it may be necessary to have two at each location. One machine selected for this service is the Ingersoll-Rand 15-T, a gasoline engine-driven unit of 82 cfm piston displacement that weighs 532 pounds without a receiver. To reduce the weight of the drill steel involved it is planned to use detachable bits with tungsten-carbide inserts, and as the 3½-inch size needed exceeds any standard type on the market, some special ones have been made up.

It was originally decided to fly equipment and workers to the various tower sites in helicopters, and this may yet be done in some cases. However, Morrison-Knudsen forces succeeded in hewing a rough road from the powerhouse to the beginning of the pass, a distance of 9 miles, and on the other end a road extends 31 miles up the Kildala River Valley. These can be used for most of the deliveries. Sikorsky helicopters dropped sectionalized prefabricated houses at the high point of the line so that a camp could be established there.

Aluminum Plant

At Kitimat, the aluminum reduction works or smelter is being constructed on a sand and gravel delta deposited in an inland arm of the sea by the Kitimat River and some small creeks. To bring the level of the low ground well above high tide, parts of the site are being filled with up to 30 feet of compacted gravel, which is hauled 2 to 3 miles. A deep-water channel is being dredged, and a wharf consisting of large concrete boxes will be floated into position, sunk and filled with gravel. The dredged material is being deposited between two rock moles to build up an area that can be used for storage. Various facilities are being provided for handling water-borne cargo, among them towers for unloading the aluminum oxide that will come in from Jamaica. All these activities are in charge of Kitimat Constructors, an organization that was formed for the purpose by eight Vancouver contractors.

Townsite

Remoteness, unfavorable terrain and climate and heavy timber cover will complicate the job of laying out a townsite, and its planning and engineering have required the services of various specialists, with Clarence S. Stein, a New York town-planner, coördinating their efforts. The firm of Mayer & Whittlesey, also of New York, is consultant for the townsite and the general master plan.

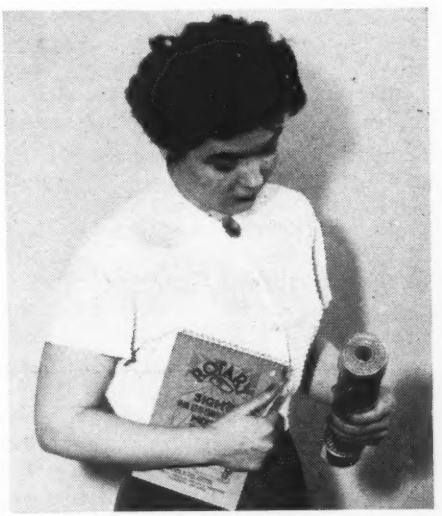
Engineering of the townsite is being handled by Swan, Rhodes & Wooster, of Vancouver, B. C. The town will be located 4 miles up the Kitimat River Valley from the smelter and on the opposite side of the stream, which will call for expensive connecting roads and bridges. The Canadian National Railways is running a branch line from Terrace, 40 miles away, and a paralleling highway is also under consideration.

Conclusion

In this account no attempt has been made to give other than a general description of the ALCAN British Columbia project, together with its most salient engineering features. In charge of the work for the Aluminum Company of Canada are P. E. Radley, manager of the British Columbia project, and his assistants, F. T. Matthias and J. S. Kendrick. W. G. Huber is vice-president and general manager of the British Columbia International Engineering Company, general consultant on the project.

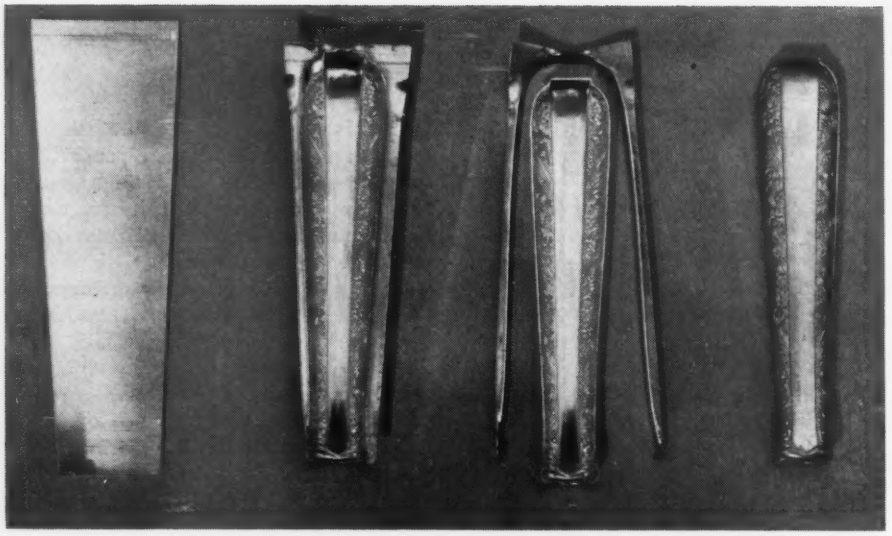
At Kemano, Karl Roestad is resident engineer and C. W. Abrahamson assistant resident engineer for the Aluminum Company of Canada. The principal resident officials for the Morrison-Knudsen Company of Canada, general contractors for the power development, are: A. O. Strandberg, project manager; R. H. Madsen, assistant project manager; R. E. Davis, underground excavation superintendent, with H. C. Spillman assistant underground excavation superintendent for the Kemano-Horetzky sections; M. R. Hackman, chief underground engineer; and R. E. Reed, area engineer. At Tahtsa, A. Perkins is general superintendent and E. Leonard is tunnel superintendent.

The writer extends his thanks to the officials of the various organizations and to the members of their staffs for the time and coöperation given him unstintingly in gathering data for these articles.



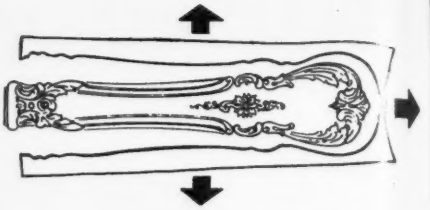
RECORD-SIZE CABLE

The comely young lady is holding a section of the cable that will be used for the 10-mile high-altitude link in the 50-mile Kemano-Kitimat transmission line where ice and wind conditions will be severe. The cable, more than 2¼ inches in diameter, consists of 108 aluminum strands surrounding a core of steel wires. It weighs 4.77 pounds per foot and has an ultimate strength of 135,700 pounds.



STEPS IN FORMING HANDLE HALF

From left to right: sheet stock, work as it comes from the striking die, trimmed piece with flash and finished handle half.



THREE-WAY SHEAR

Arrows indicate the three distinct trimming motions.

Improved Air-Powered Cutlery Shears

FINISHING the irregular edges of the halves of silver cutlery handles by hand has been eliminated by the use of an air-operated and electrically controlled machine developed by the Towle Manufacturing Company, Newburyport, Mass. Called the "tango," a name suggested by its three distinct trimming motions, it has a definite shearing action that leaves clean, smooth edges ready for soldering and does the work at a faster rate than it was performed previously.

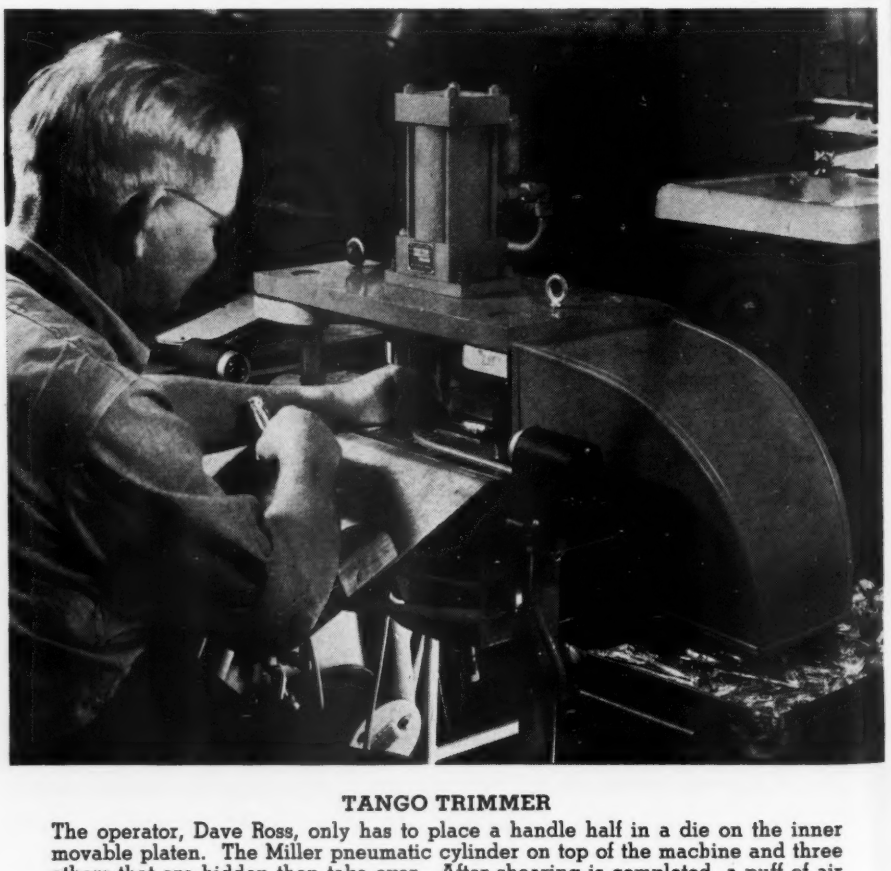
Sterling-silver cutlery handles are not solid silver, as many people believe, but only 92½ percent pure; nor are they always a one-piece shell. Actually, each hollow handle is composed of two matching halves, silver-soldered together so meticulously that, in most cases, the seam is imperceptible. The average thickness of the metal is approximately 0.025 inch, with the range from as little as 0.010 inch up to 0.050 inch in the heavy-weight lines.

A striking die forms the handles from flat sheet stock, shaping them and raising the ornamentation in one operation. One of the major problems has always been that of trimming excess metal after a piece has been struck. Either skiving or the use of a shaving die generally leaves undesirable irregularities along the edges. Towle engineers therefore devised the new method and produced the tango machine which gives near perfect results.

To obtain the best possible cut, it is necessary to shear the stock at right angles to the edges. To accomplish this, the machine was designed to give motion in three distinct directions and, in addition, a definite shearing action. Formerly, when trimming was done by a standard shimmy press, the shearing motions were at 90° angles to one another. This resulted in tearing the silver just a trifle, which has now been eliminated.

A 4-post die set with an extra-heavy bed, a movable platen and a fixed top constitutes the basic assembly of the machine. The central section of the die set is cored and machined to receive an inner guided platen in which the tools are mounted. The tango is equipped with four air cylinders mounted one on top, one each front and back, and one on one end. The top cylinder clamps the work in place; the front one moves the inner bed to shear one edge of the shell; the rear one moves the inner bed to cut the second edge; and the remaining one moves the inner bed to trim the end of the handle half.

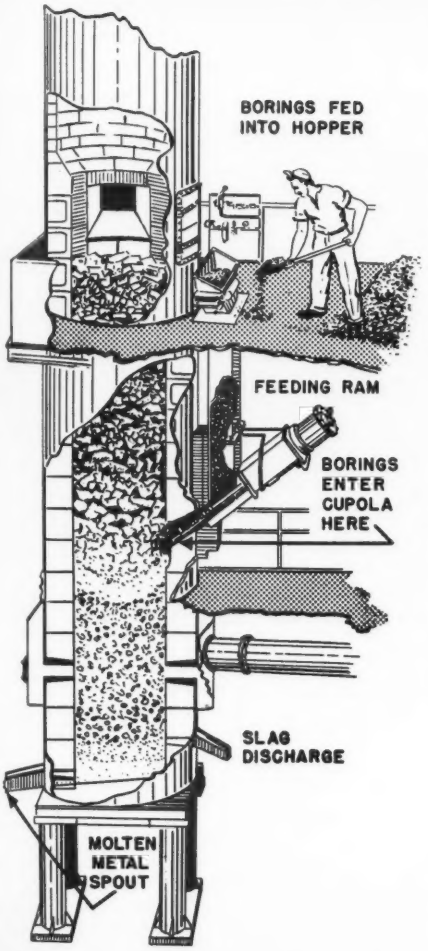
The circuit that controls this cycle of operations consists of four pneumatic delay timers wired together to actuate the four solenoid air valves that set the cylinders in motion. Air ejectors that function automatically, drop delivery chutes, an electric-eye safety cutout, work aprons in front of the machine and a tubular-steel worktable to hold tote pans complete the assembly.



TANGO TRIMMER

The operator, Dave Ross, only has to place a handle half in a die on the inner movable platen. The Miller pneumatic cylinder on top of the machine and three others that are hidden then take over. After shearing is completed, a puff of air ejects the finished work into the tote box at the right. With light stock a piece is trimmed every four seconds.

Pneumatic Device Feeds Iron Turnings into Cupola



ARTHUR Croft who runs two iron foundries in Bradford, England, has invented an air-operated device for introducing loose iron borings and turnings (the British call them swarf) into a cupola. The material is shoveled into a hopper at the cupola loading-platform level and drops through a chute of rectangular section extending down the outside of the cupola to an intersection with an inclined tube that passes through the wall. In the tube is a ram operated by an air cylinder at its outer end which causes it to reciprocate at a rate of up to 30 strokes per minute and thus feed the turnings into the cupola.

The material enters just above the melting zone and is injected into the voids between the limestone, coke and solid iron pieces making up the regular charge. These components prevent the fine material from being blown out of the stack. The temperature is normally above 1800°F in the melting zone, and the borings agglomerate quickly and sink rapidly with the rest of the charge to that zone. Introducing them at this point consequently reduces loss to a minimum and eliminates the shortcomings of methods previously used for feeding finely divided iron. In the case of a cupola that has a melting rate of 2000 pounds per hour, one-fourth of the charge may be in the form of swarf.

In the two Croft foundries, which produce about 220 tons of castings weekly, it has been found feasible to remelt around 40 tons of borings obtained from the firm's machining operations. It is claimed that this has resulted in saving 17 tons of pig iron and 23 tons of steel scrap each week. It is planned to increase the quantity of swarf utilized by buying 20 to 30 tons weekly, and this will effect further economies. At present, Croft Ltd is also injecting coke breeze (finely divided coke) into the cupola along with the borings in quantities up to 4 percent of the coke requirement. It is pointed out that granular ferroalloys may be introduced by the ram.

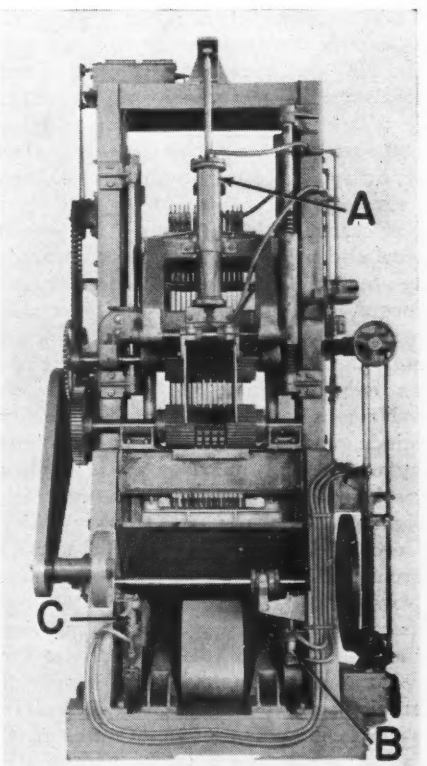
The feeder works on air from the average foundry distribution system and requires no extra labor. Mr. Croft, who recently visited America in an effort to interest foundrymen in his process, states that its adoption would save this country millions of tons of iron annually. Because of their finely divided condition and light weight, iron borings and turnings are ordinarily briquetted or consolidated with considerable loss of material before they are fed to cupolas.

Improved Gangsaw and Infeed Carriage Fast Team

TWENTY years of experience in the building of gangsaws has led the Mill Engineering & Supply Company to develop a unit that is designed to operate at high speed and to handle both cants and logs ranging widely in dimensions. Called the Sunbo, it is a double-crank semiportable gangsaw of the continuous-feed type that can be set up permanently on a concrete foundation or temporarily on heavy wooden or steel skids for reshipment as a complete unit. The feedwork consists of a variable friction gear with a large-diameter disk that is pressed against a fiber friction roller by means of an air cylinder. The disk is driven by a roller chain from a crankshaft and power is transmitted by spur gears to large-diameter bottom rolls and by roller chain and sprockets to top rolls, all of which are securely keyed and pressed on heavy shafts. Variable electric or hydraulic feed equipment also is available, but at higher cost.

Each feed roll is made up of three parts: two cast-iron fluted end sections and a cast-steel toothed middle section fitted with a scraper to remove sawdust, bark and ice from the teeth. Both sets of rolls are mounted in hinged gates which can be swung open to facilitate changing saws and to make adjustments. Built into the gates are vertical pneumatic cylinders which lift or lower the upper rolls to accommodate logs of varying diameters. Compressed air at a pressure of 80-120 psi is applied and serves also to prevent logs from slipping. Another pneumatic cylinder is used to operate a band brake on one of the flywheels of the gangsaw. A portable-type compressor supplying from 15 to 20 cfm meets all requirements. Feed is controlled by a hand wheel. It can be varied from 6 feet to 24 feet per minute and instantly stopped and reversed, if necessary.

In order to take full advantage of the productive capacity of modern gangsaws, Mill Engineering & Supply Company has designed an electrically driven infeed carriage equipped with an air motor and a pneumatic cylinder. When a log has been rolled onto the carriage and centered in V-shaped rests, or brackets if cants or flitches are to be sawed, it must be turned into the desired position—in the case of a crooked log, for example, with the bent or belly side down. This is done by the air motor. The pneumatic cylinder actuates dogs or tongs that grip the log and hold it securely as it is fed to the saw by the carriage running on 33½-inch-gauge track. An operator using such a machine can, it is reported, feed anywhere from 400 to 800 logs to a Sunbo in an 8-hour day.



SEMIPORTABLE GANGSAW

A, one of the two pneumatic cylinders that lift and lower the top feed rolls mounted in gates that can be swung open to change saws and make adjustments; B, air cylinder for the application and release of pressure on the friction disk which is part of the feedwork assembly; C, pneumatic cylinder by which the band brake of the saw's flywheel is operated.

Editorials

FLATIRON'S BIRTHDAY

NEW YORK'S celebrated Flatiron Building is fifty years old. Still pointed out to visitors on conducted tours and pictured on souvenir postcards, it has long attracted attention because of its peculiar shape and the method by which it was constructed. The edifice occupies a triangular plot where Broadway and Fifth Avenue slant across each other at Twenty-third Street like a pair of half-open scissors. When erected in 1902 by D. H. Burnham & Company, it was named the Fuller Building, but New Yorkers soon began calling it the Flatiron because of its contours, and the name stuck.

As to the manner of its construction, it was among the earliest high (21 floors) buildings in which the dead weight is carried mainly by a skeleton of metal rather than by massive-footed walls. It has been called the first "skyscraper," but the facts do not seem to entitle it to that distinction. A glimpse into an encylopedia discloses that a builder named Paxton resorted to iron frames in erecting the Crystal Palace buildings in Hyde Park, England, for an exposition in 1851. These were not lofty, but in 1883 W. L. B. Jenney designed the Home Insurance Building in Chicago, a structure of ten stories that was later increased to twelve. It was started with cast-iron columns and wrought-iron beams bolted together with the aid of angle-iron brackets. The Carnegie-Phipps Steel Company had just started rolling beams of Bessemer steel and prevailed upon the contractor to use them above the fifth floor. It is of record, also, that a young Minneapolis architect, L. S. Buffington, proposed steel-skeleton buildings in 1880 but did not construct any.

Nevertheless, the Flatiron is, in many minds, a sort of symbol of the technique by which high buildings are erected, a method that has been of far-reaching significance. To quote Harvey Wiley Corbett, for many years a lecturer on architecture at Columbia University, New York, "The transition of steel from merely strengthening stone to carrying the masonry load at each floor was the most momentous step in the history of architecture since the days of Rome. In a single bound, architecture was freed from the shackles of stone weight and made flexible beyond belief. Suddenly architecture gained a new dimension, the possibility of almost unlimited verticality. Once the skeleton is in place, construction goes on simultaneously on many floors, and the whole job can be completed quicker and at less expense than by older methods."

It has been asserted that skyscrapers came into vogue because large cities, and especially that part of New York that rests on Manhattan Island, were too small to hold enough low office buildings to fill the demand. Mr. Corbett discounts this theory and says they owe their origin to the desire of land owners to exploit small and heavily taxed plots to the utmost. They were made possible, he explains, by the development of elevators and of light, hollow tile that reduced the dead weight and likewise the fire hazard. The first elevator, installed in the Fifth Avenue Hotel in New York in 1859 by Otis Tufts, was called a "vertical screw railway." Hollow tile was invented in 1871 by Balthaser Kreisher.

The skyscraper brought a need for deep foundations. This promoted the development of rock drills in such hard-crusted places as New York City and of pneumatic caissons that could be sunk in soft or water-bearing ground. The bolts that fastened the members of the first towering skeletons together were soon superseded by rivets, and the penchant for lofty buildings thus advanced the pneumatic riveting hammer to a place of importance in the construction world.

To get back to the Flatiron Building —it will live long in the lore of Manhattan on several counts. For one thing, according to a writer in the *New York Times*, it gave us the once-popular expression "twenty-three skidoo," reportedly because policemen used to shoo loungers away from the Twenty-third Street corner of the structure.

The Flatiron also changed the complexion of the neighborhood. Known as the Madison Square District, it had traditionally been a residential area, with scores of brownstone mansions on its quiet streets. It was famed for good restaurants, such as Delmonico's, stately churches and old Madison Square Garden, scene of many notable gatherings. Here were some of the finest works of the renowned architect Stanford White. The Flatiron was quickly followed by other high buildings, and soon there was a sizable business section cutting into the even-flowing life of the vicinity.

About all that remains of the old order is Madison Square, a 6-acre park named for President James Madison. It can claim fame as the place where the game of baseball got its real start. Historians agree that the pastime in its present form was originated by Col. Abner Doubleday in 1839. One of the teams of the times was the Knickerbocker Club, composed of "gentlemen who played for exercise" on a diamond laid out in the park. It is a matter of record that they drew up the first set of baseball rules in 1845 and put them into effect in a game played at Hoboken, N. J., in 1846.

EXTENDING HIGHWAY DOLLARS

OF NECESSITY we make highways wider and more durable than ever before, and they naturally cost more than they used to. Considering the spiraling rise of wages, both in the field and in plants that furnish materials and equipment to roadbuilders, the marvel is that costs have been kept at the prevailing level. The most potent factors in holding them down have been the continual improvement in the machinery utilized and in the manner in which it is applied. In confirmation of this the U. S. Bureau of Roads states:

"Over the years there has been a continued rise in labor rates, in the price of equipment and materials, and in the contractors' overhead. If these increases had not been offset by the development and skillful use of modern construction equipment, road excavation costs today would be about three times as great as they actually are."

Speaking at the Centennial Convention of the American Society of Civil Engineers, A. N. Carter, manager of the highway division of the Associated General Contractors of America, called the changes in road-building machinery in the past 50 years revolutionary. Although rollers were perhaps used by the Romans, virtually all other machines for highway construction have originated within the past century, and their efficiency has been greatly increased in the past two decades.

Progress has been especially striking in the case of excavating equipment. Almost unbelievably, the cost of common excavation in connection with road building was 15 percent lower in the nation as a whole in 1951 than in 1923. A similar comparison as regards rock removal is not available, but outstanding advances have been made in drilling equipment and technique in the past 30 years. The power of drills per unit of weight has been appreciably increased. Methods of mounting them have notably improved, giving rise to flexible, mobile units such as wagon drills. Supersized yet readily moved drills for putting down large-diameter blast holes have become available, among them the Quarrymaster.

Betterments in drilling accessories likewise have been equally pronounced. Detachable steel bits, introduced less than twenty years ago, have markedly reduced over-all drilling costs. Great as were the resultant savings, they were matched or exceeded by tungsten-carbide-insert bits of more recent development. All in all, rock-drill designers and manufacturers have contributed their full share of "dollar stretchers" to the road-building agencies.

This and That

Methane Drained from Coal

Methane, the principal constituent of explosive firedamp, is drawn from coal seams in several European countries, notably Belgium. The primary reason for removing the gas is to make the workings safer but, in addition, much of the methane is consumed. It is drained off through long holes made with rotary drills fitted with either tungsten-carbide or diamond-studded bits. It is then compressed and distributed by pipe lines to points of utilization. The distance it can be transmitted economically depends upon its purity, it being calculated that a gas containing 96 percent methane will warrant the cost involved in carrying it 125 miles, while one of only 50 percent purity can be moved profitably only about 20 miles.

During the past two years 30 Belgian collieries have instituted methane drainage, as it is known there, and the total now drawn off exceeds six million cubic feet daily. More than half of it is put to use. Fourteen of the mines burn some of it under boilers. However, coal is the chief fuel at all the properties, so most of the gas is sent elsewhere. Much of it is mixed with other gases either as is, or after being reformed by cracking, and utilized for domestic heating and cooking. Some is also consumed in metallurgical works. In addition to serving as fuel, methane is a raw material in certain chemical manufacturing plants. In some sections there has been a concerted movement to establish industries that can make profitable use of the gas.

Extraction of methane from gassy coal seams substantially lowers the volume encountered in the workings, thereby decreasing the explosion hazard. It also permits a reduction in the amount of ventilating air circulated, and that, in turn, lessens the dust carried in suspension and breathed by the miners.

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White House Stone

Few articles about the recent $5,000,000 renovation of the White House say much about the building's exterior. The walls, which have stood well since they were put up just prior to 1800, are of sandstone from the Aquia quarries in nearby Virginia. Marble was usually used for important public edifices, but the difficulties of transporting it in that prerailroad era seem to have dictated the choice in this instance of a stone that could be procured locally.

Aquia sandstone is gray, and the White House was gray until 1814, when its exterior was badly damaged by fire. When it was restored the walls were painted white to hide the unsightly smoke smudges. The name of White House thereupon began to supplant the official title of Executive Mansion. The Aquia quarries were apparently operated by the Federal Government for some years and the stone was used for the Capitol Building, Patent Office and other Washington official structures. Little of the material has been extracted since quarrying ceased during the Civil War.

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Doom of Narrow Gauge

Narrow-gauge railroads, long scarce in America, are getting scarcer. In recent weeks, the 172.4-mile Rio Grande Southern line in southwestern Colorado threw in the sponge, and its physical equipment was sold under the auctioneer's hammer for $409,000 to Hyman-Michaels, a Chicago junk firm. In its heyday, the railway carried ore worth millions from the Dolores-Rico-Telluride region to the smelter in Durango, and was virtually the only means of getting in and out of one of the continent's most scenic mountain fastnesses.

Depletion of the metal deposits and the rise of the automobile and truck steadily ate into the little line's freight and passenger business. It was reorganized as long ago as 1938 but continued to pile up deficits, including $649,000 in back taxes owed to five counties through which it ran. In 1949, the company's 4-percent gold bonds, long in default of interest payment, sold as low as 12½ cents per $100. When the Rico Argentine and lesser mines turned to truck haulage of their ores it became certain the road could not survive, and in the end the Federal District Court presided at the fiscal obsequies.

The Rio Grande Southern was a link in the extensive transportation empire built by Otto Mears, a pioneer with vision and courage. Incorporated in 1889, it ran its first through train in 1902. The gauge was only 3 feet, as compared with standard gauge of 4 feet 8½ inches, and the tiny locomotives and cars followed a serpentine course over precipitous terrain ranging in altitude from 7000 to 11,000 feet. People got a real thrill riding the R.G.S. in those days, but the experience became even more exciting in later years when rail cars driven by gasoline engines replaced some of the locomotives. The antics of one of those vehicles while negotiating the sharp curves and steep grades gave it the name of the Galloping Goose. Tenderfoot tourists from the flatter East blinked their eyes in disbelief as the carrier eased around the circular trestlework of the awesome Ophir Loop that Mr. Mears's engineers built into the route to overcome some of Nature's obliquities. Strangely though, most mishaps resulted from avalanches rather than from the failure of the rolling stock to stay on the twisting trail of flimsy rails that weighed only 30 to 60 pounds per yard.

Mr. Mears got into railroading in a roundabout way. In 1867 he imported Colorado's first steam-driven thresher and set it to work in the San Luis Valley hemmed in by lofty peaks. To get grain to market, he carved a roadway across Poncha Pass and charged tolls for using it. The venture prospered, and he added more roads until he had a 300-mile system. The next step was to lay rails on the grades thus established. In a few years he had a network of steel reaching into the nooks and crannies of the high Colorado Rockies. Where there were no

routes, Mr. Mears is reported to have based his rights of way on Ute Indian trails. Eventually, the lines were consolidated into the Denver & Rio Grande System, and one of the prongs was thrust westward to Salt Lake City.

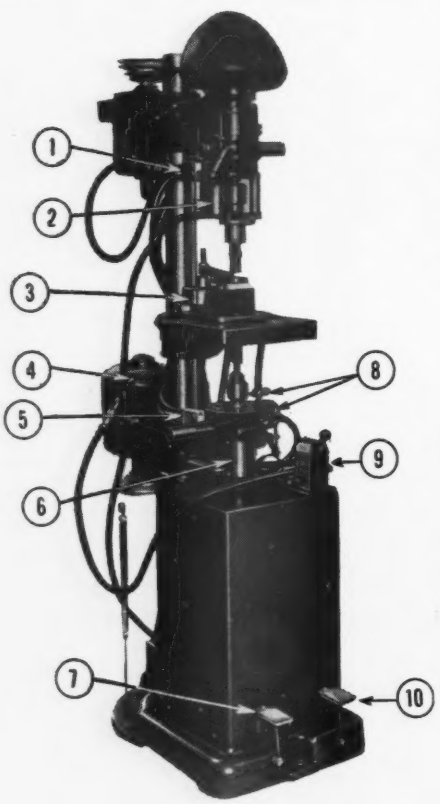
It used to be a maxim in Colorado that if you wanted to get anywhere in the state you had to ride the Rio Grande. As some sections grew more populous and others declined, those stretches of the system that were favorably located were widened, straightened and generally refurbished. Today, as the Rio Grande Western, the road's Denver-Salt Lake City link is a part of one of the transcontinental routes and you can either surmount the Continental Divide via the Royal Gorge and Leadville course or plunge through it via the 6-mile Moffat Tunnel, which saves time but gives you less fascinating upland country to look at.

Meanwhile, several of the system's subordinate tentacles that reach out into the state's mountainous byways have suffered like the R.G.S. from malnutrition and are on their way to oblivion. Passenger trains still operate three times a week over the 45-mile Durango Silverton line, and freight trains run on the 130-mile Salida-Gunnison branch and the 200-mile Durango-Alamosa link when business warrants it. These are the only remaining 3-foot-gauge railroads in the state.

While residents of communities served realize that they cannot stay the eventual demise of these roads they are somewhat sentimental about them and the R.G.S. is not being permitted to pass on without some mementos of it being retained. For example, old No. 74 steam locomotive, which did duty on the now defunct Denver, Boulder & Western Railroad before the Rio Grande Southern took it over, has been purchased by the City of Boulder along with a caboose for $2100 and will be preserved for posterity even though they spent their last days on a line that never came within 200 miles of Boulder. Similarly, the community of Telluride and the Lions Club of Dolores each acquired a Galloping Goose for $250. These vehicles are powered by Packard automobile engines. The road's receiver, Pierpont Fuller, also held out five additional pieces of rolling stock from the sale at the behest of organizations that wanted them in order to keep alive memories of rides behind the Galloping Goose that were guaranteed to bring out the goose flesh.

Drilling Machine Does Two-part Job in One Cycle

SOMETHING ingenious in a semi-automatic machine that drills both the large cavity and the small openings in novelty wooden salt and pepper shakers in one cycle has been designed and built by Crusota Engineering Company. The operation is performed by two drills: an upper with a multiple-spindle head for the ½-inch-deep shaker holes, and a lower that bores the 2½-inch cavity in the body. The sequence of operations is as follows: The work is clamped in a fixture on the table by air cylinder 3, which is actuated by opening master valve 9. Then the operator depresses pedal 10 to set the bottom drill in motion through the action of pneumatic cylinder 6. Without delay he pushes down pedal 7 to start timer limit valve 5 that controls the top drill. The latter is powered by pneumatic drill press feed 2 through the medium of a microswitch and a 3-way solenoid but is not energized until the lower drill has completed its part of the cycle. When the multiple spindle has finished its work, the upper drill withdraws automatically, the master valve is placed in the neutral position, and chips are blown from the table by air jet 4. The "one-shot cycle machine," as it is referred to, permits by-passing the solenoid to cut out the lower drill and operate the two units independently. Thus the press, with the aid of interchangeable fixtures, can be used for many varied jobs. When set up for a run on salt and pepper shakers, the machine has a capacity of 420 an hour. The pneumatic drill press feed, the air cylinders and air valves with which it is equipped are of the Mead type.



WORKING PARTS

1, Fixture actuating valve; 2, upper-drill press feed; 3, work-clamping air cylinder; 4, chip blower; 5, timer limit valve; 6, pneumatic cylinder that operates lower drill; 7, pedal that controls timer limit valve which, in turn, actuates upper-drill press feed; 8, hand valves to shut off either of the drills for work of different kinds; 9, master valve; 10, pedal that controls the 4-inch-stroke No. 6 air cylinder.

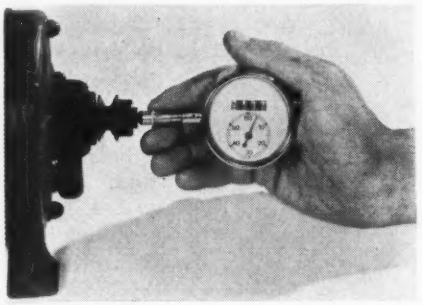
Tire Inflater Breathes New Life into "Flats"

IF ONE of your automobile tires develops a slow leak, the Jet Pac inflater will restore its pressure so that you can probably get to a service station and thus avoid the toil and trouble of tire changing on the road. This accessory—a cylinder 12 inches long and 1⅞ inches in diameter—holds 10 ounces of liquefied carbon dioxide, which is enough when converted into gas to inflate three average passenger-car tires. With it is supplied a short length of hose with connectors at each end for attachment to the cylinder and to the tire valve. Gas is released from the Jet Pac by turning a wheel valve at its outer end. The container can be refilled with carbon dioxide at service stations maintained by the manufacturer, Crosman Arms Company, Inc., Rochester 20, N. Y., or at any place that services fire extinguishers.

The inflater is also a source of power for pistols and rifles made by Crosman. Its .22 caliber rifle, for example, has a reservoir with a gas capacity sufficient for 70 shots. When the pressure drops, it can be restored by replenishing the gas supply from a Jet Pac cylinder, which contains enough carbon dioxide for approximately 500 shots.

Industrial Notes

By means of a combination revolution counter and stopwatch introduced by Montgomery & Company, Inc., one man instead of two can check the speed of rotating shafts, motors, etc. The tachometer is provided with a rubber tip. When



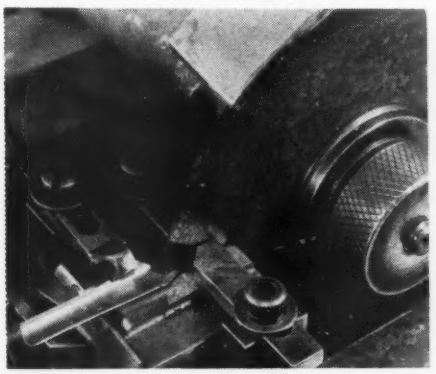
pressed lightly against a revolving member the counter is idling; when hard pressure is brought to bear on it both the counter and the stopwatch are simultaneously engaged and caused to run. After a lapse of from 15 to 60 seconds, pressure is released and revolutions are read directly from a dial. Recommended running time is one minute; maximum speed 5000 rpm. Counter is reset to zero by turning a knob, which also automatically rewinds the watch.

Chemical and other plants where corrosive or hazardous liquids are carried in pipe lines may be interested in a valve shield that protects the operator from injury by spraying acid should the valve-stem packing fail. It is molded of neoprene in the shape of a flower pot with a hole in the bottom of slightly smaller diameter than the valve stem. With the wheel removed, it is pulled down over the stem so as to cover the packing gland. If necessary, the edge of the skirt can be trimmed to fit the

body. Because of its flexibility, the shield can be turned back to inspect the valve or to tighten the packing-gland nut. Called Chex-Spray, the safety device is at present available in three sizes for ¾- to 4-inch valves. The idea originated several years ago in one of du Pont's chemical plants and, when found practical, was passed on for commercial development to the Industrial Products Company, which is manufacturing the shield. Larger ones will be made if there is sufficient demand for them.

At General Motors' New Departure Division in Sandusky, Ohio, turnings from machining operations are collected, put through a grinding machine, then transported by pneumatic tube to a storage hopper at a railroad siding. Periodically the material is chuted into railroad cars and shipped to steel mills.

At the annual show of the Royal Agricultural Society of England, General Electric Company, Ltd., exhibited an "in-sack" grain-drying apparatus. It consists essentially of a concrete air chamber with gratings on top on which the sacks of grain are laid. Into the box

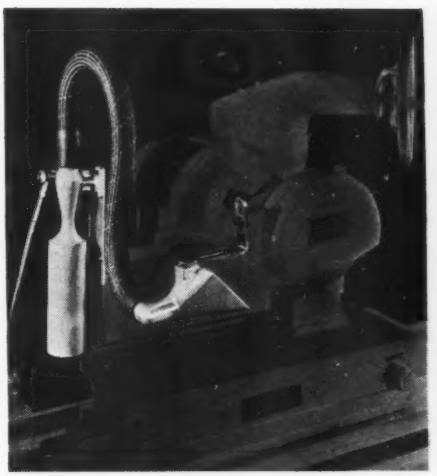


A THIN CUT

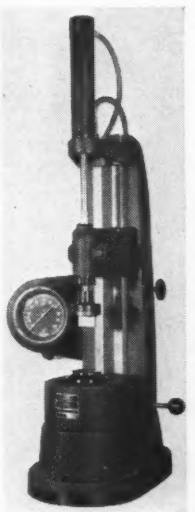
A Norton "alundum" grinding wheel is shown slitting the nib of a pen point at the Esterbrook Pen Company's factory, Camden, N.J. The wheel, which is the thinnest Norton makes, is six-thousandths of an inch thick—about twice the width of a human hair. It is 3½ inches in diameter and rubber-bonded.

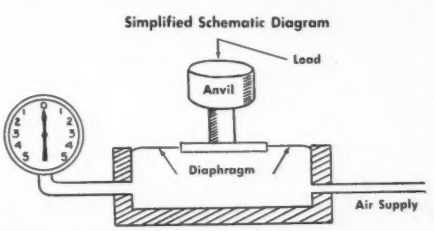
is blown heated air coming from a 1-hp, 15-inch-diameter fan that has a built-in electrical heating element. With the air warmed 25°F above the temperature of the atmosphere, about 1 percent of the grain's moisture content can be extracted per hour. The equipment will dry twenty sacks at a time.

Small dust collectors for attachment to surface and other grinders have been announced by The Vulcan Tool Company. They are available in two sizes: Series 200, with a capacity of 24 cubic inches for wheels up to 2 inches in diameter, and Series 700 with a capacity of 56 cubic inches for wheels with a diameter of 7 inches and less. The units are operated by a needle valve from a shop air line and are mounted on the grinding-wheel guard or close to the wheel. The cup or inlet is positioned to insure positive removal of the dust as the wheel moves up and down, and the container is mounted alongside the grinder. The collectors require no refills and are easy to install and keep clean.



To test the resiliency of springs, piston rings, cork, rubber and other elastic materials, Link Engineering Company has produced a pneumatic machine for laboratory or high-speed production-line use. It consists essentially of an air cylinder, a fixed anvil, a diaphragm and air chamber, a pressure regulator and a gauge. To test 50-pound springs, for example, a 50-pound weight is placed on the anvil and the air-pressure regulator is adjusted until the gauge setting is at zero. A spring of known and approved properties is then substituted for the weight, and the cylinder piston is lowered until the dial reading is the same as before. Next a stop is set to limit the ram movement, thus eliminating the height variable and reducing the operating cycle to two seconds, it is claimed.





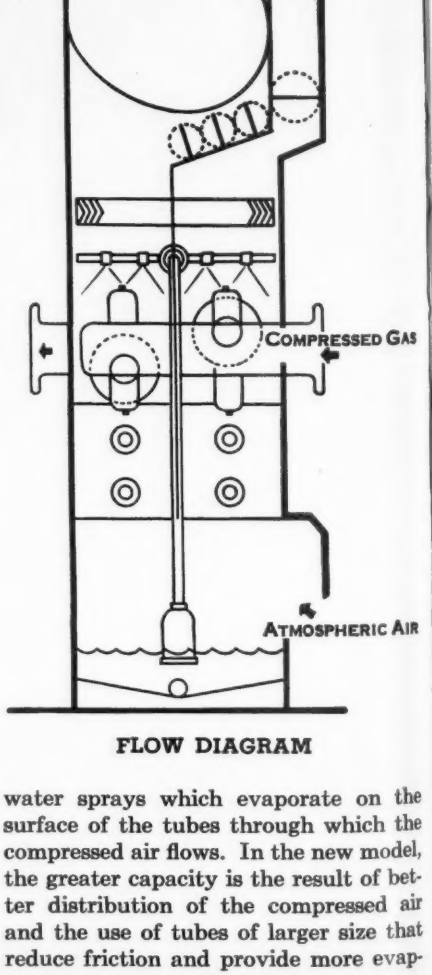
Routine testing can then proceed. Any variation in load over or above the zero setting is registered on the gauge in pounds and is equivalent to the diaphragm pressure required to offset the pressure exerted by the ram on the anvil through the spring. Different models are available with a capacity range of 10 to 1500 pounds and for work 13 to 17½ inches high and 2⅝ to 6 inches in outside diameter. Both hand- and foot-controlled units are available.

White tape with a red stripe running down its center is used in General Electric factories to "fence in" any area where a temporarily hazardous condition exists. It may enclose high-voltage electrical equipment, an unguarded flywheel or anything else that is dangerous. Plant personnel is cautioned not to reach over or crawl under the barriers.

Fluorescent inspection is facilitated, it is reported, by a new source of ultraviolet rays announced by Ultra-Violet Products, Inc. The fixture is dust- and vaporproof and has three 40-watt tubes made of a special glass that is said to increase fluorescence to the point where inspection can be done in a normally lighted area. The tubes, rated at 3000 hours, start instantly, burn cool and require no warm-up period to reach peak emission and no cooling-off period before restarting. The new industrial-type Model XXX-40 Blak-Ray covers an area of 20 to 40 square feet with intense long-wave ultraviolet radiation. Fluorescent inspection is proving valuable in detecting decay and fungus in agricultural products; in determining whether transparent spray and other coatings, fillers, etc., applied to metal, wood, rubber and plastic cover all surfaces; in spotting flaws in metal castings and machined parts; and in revealing defects and dye variations in textiles.

By installing a network of General Electric Company strip heaters under the floor of its 60-ton bottom-dump mine cars, Atlas Car & Manufacturing Company, Cleveland, Ohio, prevents ore from freezing and sticking.

Through improvement in design, Niagara Blower Company has increased the cooling capacity of its Aero aftercooler for compressed air or gases from 25 to 75 percent, according to a recent announcement. Air at atmospheric wet-bulb temperature is the cooling medium, and cooling is effected by continuous water sprays which evaporate on the surface of the tubes through which the compressed air flows. In the new model, the greater capacity is the result of better distribution of the compressed air and the use of tubes of larger size that reduce friction and provide more evap-



FLOW DIAGRAM

Picture shows a 400-ft. span Sauerman Drag Scraper machine, powered by a 150 h.p. motor, backfilling an empty stope at a large nickel mine in Canada. Scraper cuts into side of hill and moves earth down to a raise at rate of 2,000 cu. yd. a day.

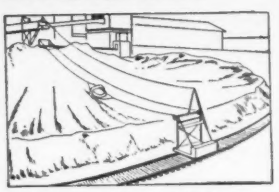
Slash your handling costs with a

SAUERMAN SCRAPER

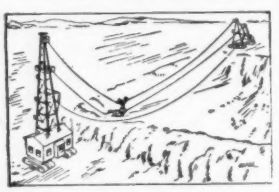
In a Sauerman Drag Scraper Machine you find a profitable combination of digging power, haulage speed, long reach, simple operation, economical maintenance.

An important exclusive feature of the Sauerman scraper machine is the Crescent scraper. Because of its streamline design, the "Crescent" requires less linepull than any other type of scraper, both in excavating and in conveying. It penetrates hard material with the ease of a plowshare, gathers a full load in a few seconds, then rides its load speedily to the dumping point where it makes an instantaneous, clean dump.

Sketches below show two of the many types of Sauerman Scraper Machines for different material-handling requirements.



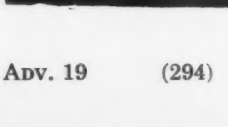
Sauerman Scraper Stockpiler



Mobile Scraper with Towers

The operator, sitting in a comfortable control station, easily guides the scraper over a large area. Automatic shifting of the tail end of the machine is provided where desired. Power requirement is moderate. Installation and upkeep costs are surprisingly low. Made in a wide range of sizes covering the capacity needs of large and small projects.

Write for Sauerman Catalogs A and E, showing how to use drag scrapers most effectively for pit excavation, stripping, pond cleaning; stockpiling, etc.



SAUERMAN BROS., INC.

548 S. Clinton St. Chicago 7, Illinois

orating surface. The unit is designed for installation outdoors and equipped with an automatic control that shuts off cold air from the spray chamber to prevent freezing. It is said to cool compressed air below atmospheric dry-bulb temperature and thus minimize condensation in air lines that may damage pneumatic tools, paint sprays and plant processes.

With a pressurized dispenser containing 12 ounces of Sherolite—a liquid seal—it is an easy job, it is said, to cover exposed engine wiring, ignition lines, brass terminals, porcelain or spark plugs and the like and thus protect them against moisture. The spray is a product of Reynolds Industries, Inc.

After eight years of research, General Electric Company has announced the development of an alloy that has overcome the limitations of conventional copper field windings in large generator rotors revolving at high speed and under high temperatures. Called Cond-Al, it is composed of aluminum and very small quantities of iron, magnesium and silicon and has enabled the company to undertake the manufacture of steam-turbine generators that are said to be 35 percent more powerful than any now in existence. The first of four units to incorporate the lightweight, highly conductive alloy is slated for completion this year. Each is rated at 216,000 kva and will operate at 3600 rpm. The largest and most powerful machine of this kind now in service is a 160,000-kva turbogenerator in the plant of a midwestern utility.

QUOTES

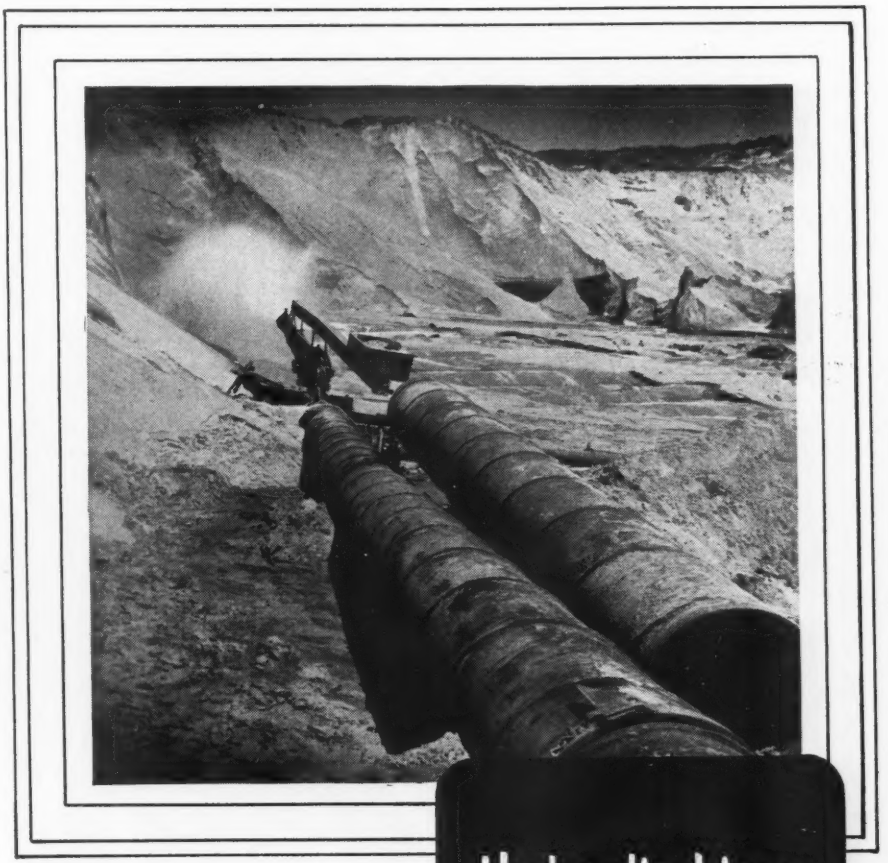
—FROM HERE AND THERE

Moving Grain with Air

"Fluidization, when used to describe the movement of solids, means that particles are in a free-flowing state. They then can be transported through pipes by increasing the air pressure. Engineers at West Virginia University decided to try this idea on wheat. They fed the grain into the top of a tall narrow cylinder and pumped in compressed air at the bottom. Wheat was taken out of a discharge pipe at the middle of the cylinder. They found that air under low pressures would move a ton of wheat an hour through a 1-inch pipe 75 feet long. This delivery line had 3 right-angle turns and a U-turn in it. One pound of air moved 20 pounds of grain when it was in this fluid condition. Engineers said even greater efficiency would result if grain was ground.

"Experiments at Battelle Memorial Institute, Columbus, Ohio, indicate that shelled corn can be fluidized. This holds some interesting possibilities for drying.

Familiar Scenes
IN MINING SERVICE

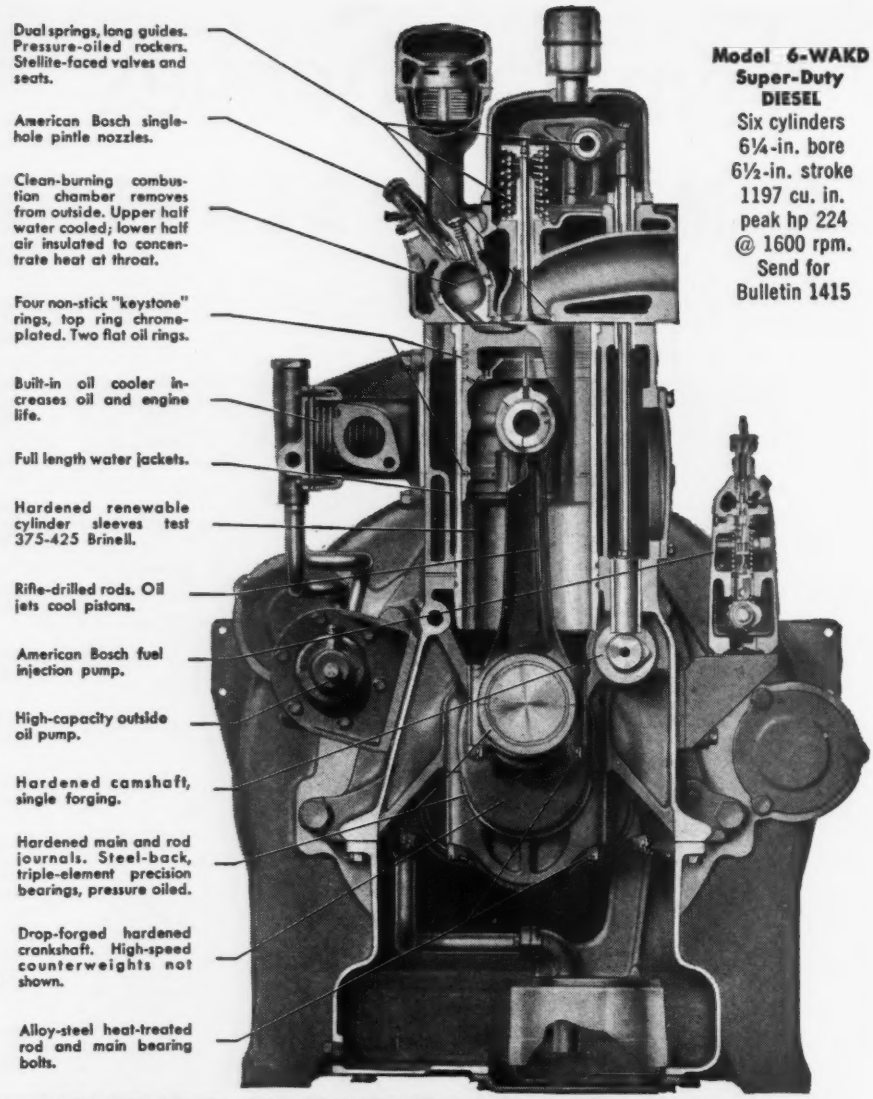


Hydraulic Lines by NAYLOR

The extra strength and safety made possible by the exclusive Naylor Lockseam Spiralweld structure makes Naylor light-weight pipe the answer for high pressure hydraulic lines. Light weight, ease of handling and installation, and high-speed assembly with Naylor Wedge-Lock couplings are other reasons why you see so much Naylor Pipe in mining service.

Write for Bulletins 507 and 513

Naylor Pipe Company
1245 E. 92nd St., Chicago 19, Ill.
New York Office:
350 Madison Ave., New York 17, N.Y.


Dual springs, long guides. Pressure-oiled rockers. Stellite-faced valves and seats.
American Bosch single-hole pintle nozzles.
Clean-burning combustion chamber removes from outside. Upper half water cooled; lower half air insulated to concentrate heat at throat.
Four non-stick "keystone" rings, top ring chrome-plated. Two flat oil rings.
Built-in oil cooler increases oil and engine life.
Full length water jackets.
Hardened renewable cylinder sleeves test 375-425 Brinell.
Rifle-drilled rods. Oil jets cool pistons.
American Bosch fuel injection pump.
High-capacity outside oil pump.
Hardened camshaft, single forging.
Hardened main and rod journals. Steel-back, triple-element precision bearings, pressure oiled.
Drop-forged hardened crankshaft. High-speed counterweights not shown.
Alloy-steel heat-treated rod and main bearing bolts.

Model 6-WAKD Super-Duty DIESEL
Six cylinders
6¼-in. bore
6½-in. stroke
1197 cu. in.
peak hp 224
@ 1600 rpm.
Send for
Bulletin 1415

WAUKESHA Diesel

184

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS., NEW YORK, TULSA, LOS ANGELES

Edgar S. Downs reports that an air flow of about 8 feet per second is enough to make a bed of corn 'boil.' When grain is supplied with the necessary quantity of air, the particles set up currents much like a fluid when heat is applied.

"Downs says that temperature differences in such grain tend to be small. This is due to the movement and consequent mixing. This feature would be advantageous in batch-drying, as it would cause all the grain to dry evenly. Also, better heat transfer might be effected between the air and grain. This could result since the film of dead air surrounding each particle in ordinary batch operations would be 'scrubbed off' frequently by the movement of kernels against each other.

"Since lighter material tends to rise to the top of a fluidized mass, the new system may permit separation of trash from grain."

From Capper's Farmer, September, 1952.

Safety Tip

"Information and tests show a real danger of exploding dynamite caps if a two-way radio transmitter is used within 20 feet of an uncoiled wire on the caps. Never carry dynamite caps in a car or truck equipped with two-way radio. Caps should be transported in metal containers, never opened near a transmitter. A transmitter should not be operated within 50 feet of any electric blasting work."

Pennsylvania Highway Department

Roof Bolting

"In 1947 roof bolting was introduced extensively and it is estimated that more than 2,500,000 bolts are now being used a month in about 600 mines. In West Virginia, over 5,000,000 roof bolts were used to produce 99,000,000 tons of coal at 170 mines in 1951. The use of roof bolts has permitted more effective and safer use of loading machines and shuttle cars."

Lewis E. Young, of Pittsburgh, Pa., in a talk on coal-mining mechanization at Stoke on Trent, England.

Paint Spray Guns

"Increased use of mechanical equipment, such as spray guns, has been suggested by the head of a leading contractors' organization in the painting field as the ideal solution to many problems confronting builders. According to J. W. Zucker, president of the Painting and Decorating Contractors of America, mechanization can help painters meet the competition of newly developed plastic-type coatings and can increase the efficiency of painting work to the advantage of builders and the public alike."

Construction Equipment, August, 1952

Books and Industrial Literature

A new textbook on mathematics, entitled *Basic Mathematics for Engineering and Science*, unifies algebra, trigonometry and analytic geometry into a first-year college course for students of engineering and science. The authors—Dr. W. R. Van Voorhis, professor of mathematics, and Dr. E. E. Haskins, teacher of mechanical engineering, both at Fenn College—have presented the subject matter in such a way that a student with only a knowledge of high-school algebra and plane geometry will be assured a working knowledge of basic mathematics in preparation for calculus. The introduction of the 619-page book is devoted to functional definitions and relationships, with frequent references to practical applications. Formal work is interspersed with conceptual ideas to stimulate interest, and there is a chapter on applied statistics of importance in the industrial world. Problems at the end of each chapter are designed to acquaint the student with the terminology and procedures of the engineering sciences and, as in most textbooks of this kind, answers to odd-numbered ones are given at the back of the book. Many charts and graphs and eight math tables are included, making all reference material available in one volume. *Basic Mathematics for Engineering and Science* is published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price, $7.65.

The Handy Book Length Company has published a compilation of tolerance tables of convenient size—4x5½ inches—as a ready reference for determining tolerance dimensions for both machine operators and designers. It is in two parts: the first gives standard industrial tolerances in fractions with 3-place decimal equivalents and the second contains 2-place decimal tolerances with the nearest fractional equivalents. Entitled *Handy Tolerance Tables*, the booklet may be purchased from the company at 3507 Seventeenth Street S.W., Canton, Ohio. Price $2.00.

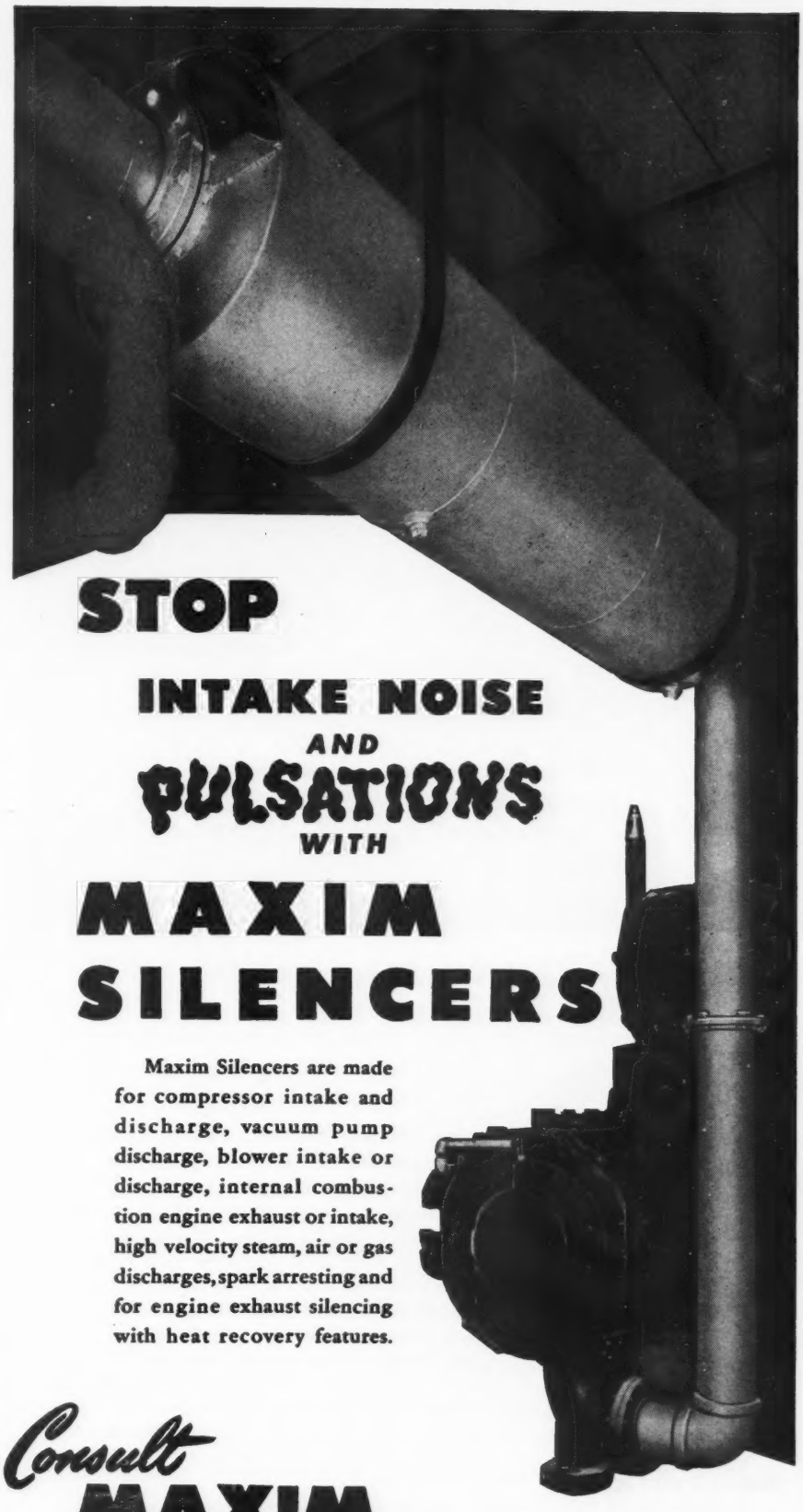
A folder on sash maintenance which tells how to deal with common troubles encountered in keeping metal and wood sashes in good condition is being distributed by The Tremco Manufacturing Company, 8701 Kinsman Road, Cleveland 4, Ohio. Write for No. 26-B-2.

Thermoid Company, Trenton, N. J., has published a bulletin describing its new "basic-five" color-coded line of multi-purpose industrial hose. The pamphlet gives construction details, sizes, pressures and recommended uses. Copies are distributed free of cost by the manufacturer.

Naylor Pipe Company, 1230 E. 92nd Street, Chicago 19, Ill., has announced a new bulletin—No. 525—on its standard and special fabricated fittings that includes specifications and design prints. It is intended to help managements modernize piping systems.

The Garlock Packing Company, Palmyra, N. Y., has available for distribution a 6-page folder on its molded cups for pump pistons, hydraulic service and pneumatic equipment. It contains a complete description of the cups, gives typical applications and service data and lists sizes and part numbers.

A new bulletin issued by Miller Motor Company contains engineering, design and mounting data, including drawings, on its



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INTAKE NOISE AND PULSATIONS WITH

MAXIM SILENCERS

Maxim Silencers are made for compressor intake and discharge, vacuum pump discharge, blower intake or discharge, internal combustion engine exhaust or intake, high velocity steam, air or gas discharges, spark arresting and for engine exhaust silencing with heat recovery features.

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THE MAXIM SILENCER COMPANY

61 Homestead Ave., Hartford 1, Connecticut, Dept. W. L.

Gentlemen: Please send me your bulletin on silencers for
☐ Compressor Intake ☐ Internal Combustion Engines
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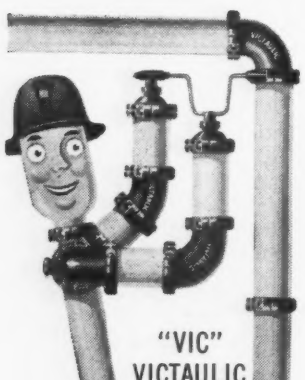
THE VICTAULIC® METHOD OF PIPING

EASIEST WAY TO MAKE ENDS MEET



Sizes ¾" through 60"

TEES . . . ELBOWS . . . REDUCERS . . . the Victaulic Method features a complete line of modern, top efficiency, Full-Flow Fittings for use with world famous Victaulic Couplings!

The Victaulic Method assures a complete, modern system of piping . . . fast, efficient hook-ups that simplify and streamline construction . . . cut costs! Victaulic Couplings offer easy-to-install, leak-proof connections . . . a union at every joint . . . assured trouble-free service under pressure or vacuum. Victaulic Full-Flow Fittings specially designed for use with Victaulic Couplings provide wide adaptability and complete versatility in construction. And to make the Victaulic Method complete—"Vic-Groover" Tools groove standard pipe easily and quickly . . . provide handy, portable equipment for preparing pipe right on the job!

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28th VICTAULIC YEAR

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Canada: Victaulic Co. of Canada Ltd., 406 Hopewell Ave., Toronto 10
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complete line of air cylinders and is arranged to save engineers and designers time in selecting types for given jobs. Bulletin A-105G may be obtained from the company at 2040 N. Hawthorne Avenue, Melrose Park, Ill.

The Unseen Factors in Flotation is the subject of a bulletin—No. F10-B13—recently made available for free distribution by the Denver Equipment Company, 1400 Seventeenth Street, Denver, Colo. "The unseen factors," says the author, Leland Logue, "are those which affect the economic recovery and are not shown by the assays or analyses of concentrates and tailings."

Bulletin 718 issued by HPL Manufacturing Company, 15147 Miles Avenue, Cleveland 28, Ohio, describes its fast-tooling method of making precision stampings in small lots for experimental work or uses where quantity requirements range from 25 to 25,000. Its facilities lend themselves well to the fashioning of pilot models of new products where design changes are apt to be frequent. Typical shapes are pictured.

O-rings are the subject of a 16-page bulletin prepared by International Packings Corporation, Bristol, N. H. It contains brief but comprehensive data on the design, manufacture and application of these static and dynamic seals, discusses the properties and characteristics of the rubber compounds of which they are made, and includes other essential information in the form of charts.

Hercules Powder Company, Wilmington, Del., will mail upon request a folder on Vinsol, a resinous product used as an air-entraining agent in cement and concrete. It briefly discusses the advantages of concrete containing microscopic bubbles of air, methods of production and factors that influence air entrainment. The leaflet lists suppliers of the neutralized Vinsol solutions used for the purpose.

Cone-Drive Gears, a division of Michigan Tool Company is offering an illustrated bulletin dealing with its flexible standard-bore couplings for worm, gear and electric-motor shafts, as well as with special types. Data include tables of capacities, specifications and information on how to order, and exploded views show how couplings are assembled and uncoupled. Address requests for Bulletin CDC-52 to Denham & Company, 925 Book Building, Detroit 26, Mich.

The Answer to Industrial Dermatitis is the title of 6-page catalogue descriptive of Skin-Cote, a barrier material made by The Boyer-Campbell Company that is said to resist the penetration of many solvents that irritate the skin. The publication contains a comprehensive list of chemicals or processes with the type of Skin-Cote recommended for each and is obtainable by addressing the company at 6540 St. Antoine Street, Detroit 2, Mich.

The Geophysical Instrument Company, a division of Georator Corporation, Arlington 9, Va., has announced the publication of Circular 101 which gives a detailed description of its new Geovolt apparatus developed for the purpose of prospecting for certain mineral deposits by the well-known self-potential or spontaneous polarization method. In service, the natural earth voltage is recorded at a series of laid-out stations, and from measurements so made is plotted a map on which the point of maximum geovoltage is often directly over the ore body. Anyone interested can obtain a copy of the circular upon request.